INFLUENCE OF VALVE SETTING ON EFFICIENCY OF INTERNATIONAL HARVESTER CO. GASOLINE ENGINE

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Influence of Valve Setting on Efficiency and Capacity of a 25 Horse Power International Harvester Company Gasoline Engine

A THESIS

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MECHANICAL ENGINEERING

MAY 28, 1914

G. F. Gebhardt

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L. C. Monin

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INTRODUCTION

The object of this thesis is to determine the influence of different valve-settings on the efficiency and capacity of a 25 horse power International Harvester Company Gasoline Engine. In order to do this the test was divided into two parts: Part I, the efficiency and capacity before shifting the cams; Part II, the efficiency and capacity after cahnging the relative positions of the cams and cam-shaft.

Part I - The valves were set according to the builder's direction to give maximum opening of the inlet and exhaust valves without interference. Three tests were run , two of which were selected as typical. Tabulated data, full and light spring indicator cards, and a sample calculation are included.

Part II - The cams of the intake were shifted the proper number of degrees to give a greater period of opening, the adjustment of the clearance space giving the proper timing. The period and timing was theoretically better than could be obtained without a resetting of the cams. Three runs were made, one of which was selected as typical, the other two being discarded on account of a faulty gasoline line. Tabulated data, full and

light spring indicator cards are included.

Edward [illegible]

Oscar Goetz

DESCRIPTION of the ENGINE

25 Horse Power International Harvester

Company Gasoline Engine.

This 25 Horse Power two cylinder 4 cycle vertical gasoline engine of the International Harvester Company is located in the Gas Engine Laboratory, Machinery Hall, Armour Institute of Technology. It is equipped with a gasoline mixing valve. The gasoline is pumped from a weighing tank, placed slightly higher than the pump. Any excess gasoline forced to the mixing valve passes through the overflow back to the tank. The pump is operated by the cam shaft.

Base

The base is made of one piece of cast iron well ribbed to insure strength. There are large projections on the inside of the base, running from one side to the other; these direct the splashed oil to the three main bearings. Detachable parts of the base are the four cover plates for the openings of the crank case and the three main bearings. There are two vent valves, one at each end of the base, well out of the way of the path of the oil splash. Oil is led to the bearings and crank case through these vents as well as through two oil cups similarly located.

Cylinder

Two cylinders are interchangeable, that is, parts of one cylinder may be substituted for parts of the other. They are made in two parts, the body and the head. The head having the valves flush with the inside surface. The cylinders are water jacketed and the circulation is governed by valves located in the rear of each cylinder.

Crank and Bearings

The 4 inch crank shaft is made of good steel stock, forged in one piece. It runs in three babbitt metal bearings, set on finished surfaces on the inside of the base. The adjustment and alignment is accomplished by the use of metallic liners. Each bearing is fitted with a tongue which fits in a corresponding groove on the inside of the base. This makes a riged bearing against side-thrust.

Valves

Four poppet valves are mounted in separate cages, each having a spring, two nuts (one a lock for the other), and a cotter-pin. The cages are placed in the cylinder head and arranged so that the valves may

be removed for re-grinding by merely loosening two cap screws. See figures 3 and 4. Furthermore the exhaust and intake cages are interchangeable and any part of one may be substituted for the other.

Ignition.

The ignition system, see figure 8, is of the make and break type, either batteries or an outo sparker may be used. In the following tests batteries were used because of a faulty governor on the auto sparker. The ignitor consists of a cage bolted on a ground seat to the side of the cylinder, which prevents leakage of the gas. The internal spindle is movable and insulated from the cage. Length of contact and time of ignition is governed by two knurled nuts attached to the ignitor near the base of the engine. For quick adjustment there are two positions, such as late ignition for starting and early ignition when the engine is running at its rated speed. Besides these two quick adjustmente the system has a slight adjustment for general late or early ignition. This is done by means of a coupling nut with a right and

left thread which makes it possible to adjust the spark while the engine is running.

Governor

Figure 9 shows a cut of the fly ball governor. It is spring controlled and is not affected by momentary changes in speed due to shockes or sudden vibrations which might occur during operation. The governor operates the throttle within the mixing valve, shutting off the supply of gasoline upon excess speed, and opening the throttle valve at speeds lower than normal. Similarly if the load is suddenly thrown on or off, the engine speed will not vary much. By thus regulating the gasoline vapor and air according to load requirements, the fuel consumption may be made a minimum. The governor may be regulated for various speeds during operation.

Mixing Valve

Figure 10 shows an exterior view and figure 11 shows a cross section of the mixing valve. The gasoline is pumped to a reservoir from which it is introduced into the mixing chamber through a cone shaped valve or nozzle at D, which reduces it to a fine spray. Air is admitted in direct-proportion to the opening of

the balance throttle valve V, which is actuated by the air piston P, which responds to the suction of the engine. The spring on the horizontal stem drawing the valve back to the closed position after each suction stroke. With light loads and when starting, all the air passes through the opening D, in an auxiliary air valve E, the stem of which is attached to the dash-pot F. All the air then comes in contact with the gasoline vapor and produces a homogeneous mixture, insuring regular explosions and easy starting. With heavier loads, the increased suction pulls down the dash-pot Fand opens up an annular passage around the outer edge of the auxiliary air valve, allowing additional air to pass through as indicated by the dotted arrows. This arrangement is provided so that the amount of gasoline aspirated at different loads will be in proportion to the air admitted, and the mixture will not become to rich to fire easily.

Air Starter

An air compressor driven by a separate motor supplies air to a tank in the laboratory and a pressure of 280 pounds may be had if necessary. However, the

engine has been started on as low a pressure as 50 pounds. To start the engine the operations are as follows: the intake valve gear of the left cylinder is thrown out; the lever of the three-way valve, figure 12 is turned to the left; the air starting valve is turned down, see figure 13, and compressed air admitted to the engine. The engine is run this way until the gasoline vapor of the right cylinder explodes, probably three revolutions. After the engine begins to run on the right cylinder the levers and valves are returned to their original positions, which allows gasoline vapor to enter the left cylinder. When the engine reaches the required speed the knurled knobs are turned to the right, which advances the spark.

Cooling Water

Water used for cooling is taken from the city main and is discharged to the sewer. For testing purposes the water is discharged into large weighing tanks and then lead to the sewer.

Indicator Motion

The indicator motion consists of a small shaft driven by a chain from the main shaft. Two eccentrics of one and one half inch throw gives a reduced motion of the piston. The indicator cocks are situated in the head directly above the reducing motion.

PART I.

The Efficiency and Capacity of a 25 Horse Power International Harvester Company Gasoline Engine before changing the relative position of the cams and the shaft.

Preliminary Work

The first part of the preliminary work consists chiefly of putting the engine in running order. Having stood idle for nearly a year, it was necessary at times to turn over the flywheel with a crow-bar. The face of the flywheel was marked every ten degrees, starting with the upper dead-center as zero. The valves were approximately adjusted, and the check valves in the gasoline line repaired. The engine was then run for a few hours to insure free movements of all parts. The following itemized repairs were then made.

<u>Gasoline Piping</u>

The entire gasoline line, overflow chamber and mixing valve was removed.

The pump was examined, lubricated and repacked.

The ball of one check valve was replaced by a conical brass check.

All joints were sealed with a cement compound to prevent leakage.

To eliminate priming of the pumps as well

as liability to becoming air bound, the supply tank was pituated higher than pump cylinder.

Indicator Motion

The play in the indicator motion was taken up by filing the ends of the eccentricc straps.

The indicators were put in place without their springs, and vertical lines drawn 30° before and after dead center. The lines coincided, showing that the motions were as perfect as necessary for all practical purposes.

Calibration of Scales.

The brake and gasoline scales were calibrated. The scales were adjusted for a balance at no load and when loaded and balanced the error was neglegible.

The cooling water tanks, having been calibrated a short time previous, were not re-calibrated.

The thermometers were calibrated before and after each run, showing no appreciable error.

Indicator Springs.

The indicator springs were checked against a pressure gauge préviously calibrated. An air

pressure from 0 to 240 pounds was used, taking intervals of 10 pounds up and down. The results were plotted against the pressure gauge and the errors were small; the error at the lower pressures neutralizing those of the greater pressure.

Valves

The cams are keyed to the cam shaft, and to prevent side motion set screws were used. With out removing the keys there is only one adjustment, that is to make the valve rod longer or shorter, varying the clearance. By lengthening the reach rod, the clearance is decreased, causing an earlier opening and later closing. By shortening the rod the clearance is increased, resulting in a later opening and closing.

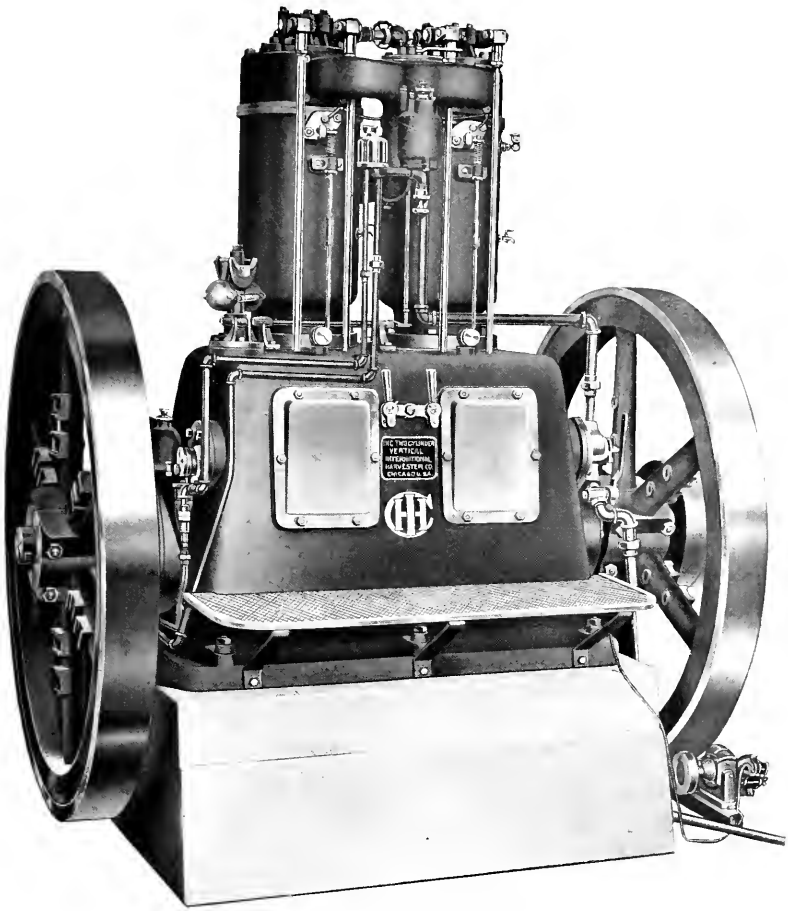

IHC TWO CYLINDER
VERTICAL
INTERNATIONAL
HARVESTER CO.
CHICAGO U.S.A.

Figure 1.

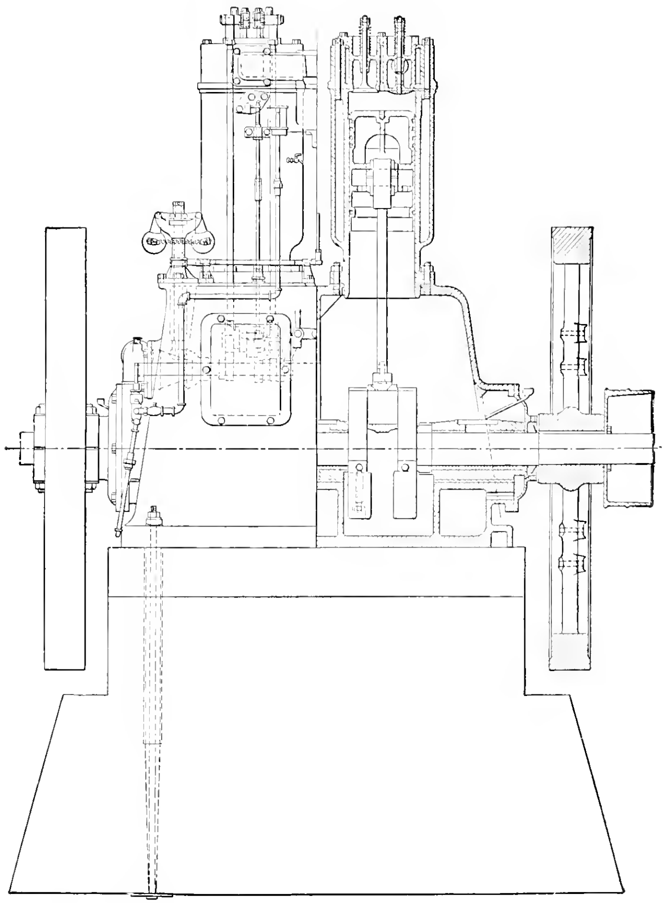


Figure 2.

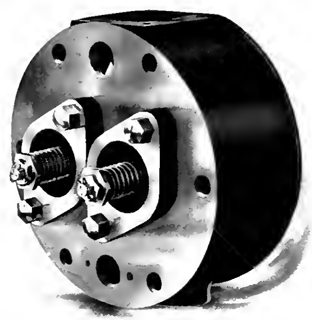


Figure 3.

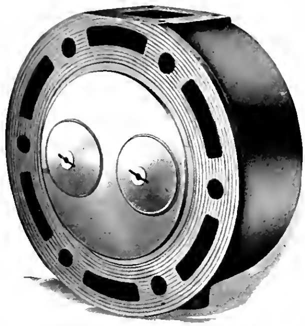


Figure 4.

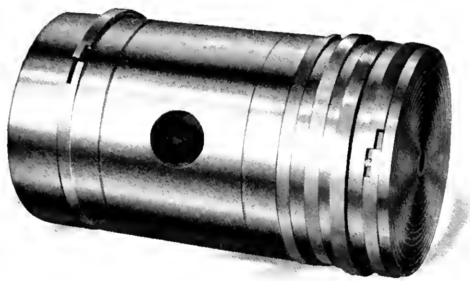


Figure 5.

Figure 6.

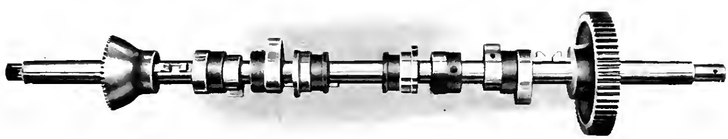


Figure 7.

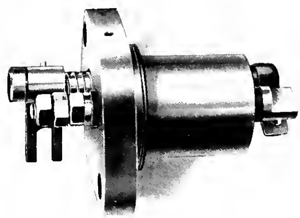


Figure 8.

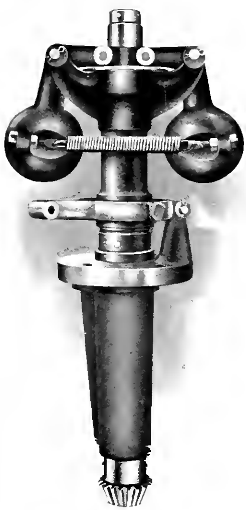


Figure 9.

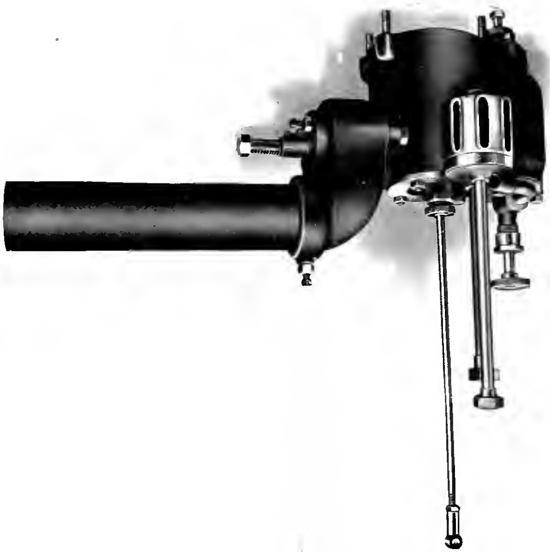


Figure 10.

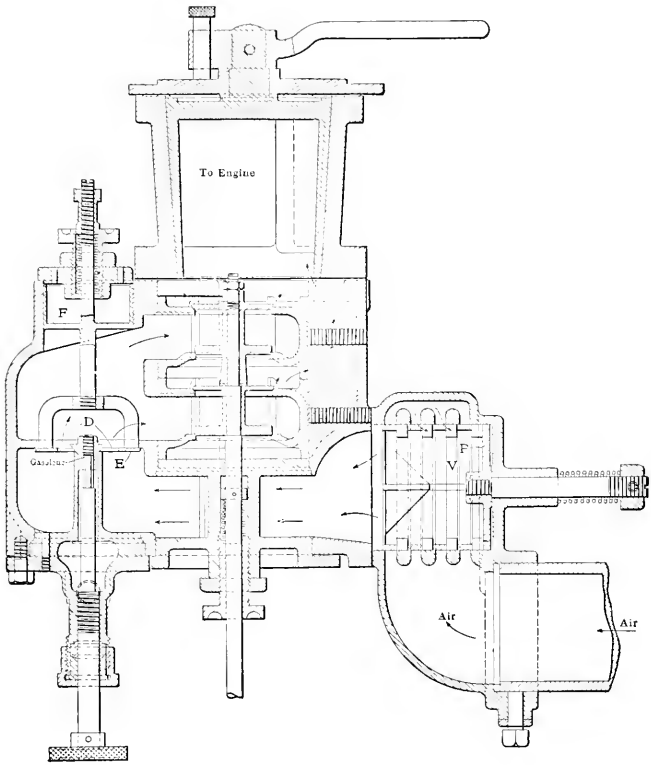


Figure 11.

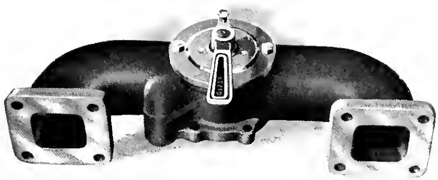


Figure 12.

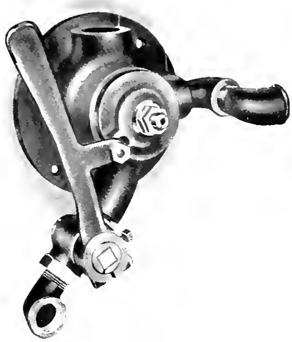


Figure 13.

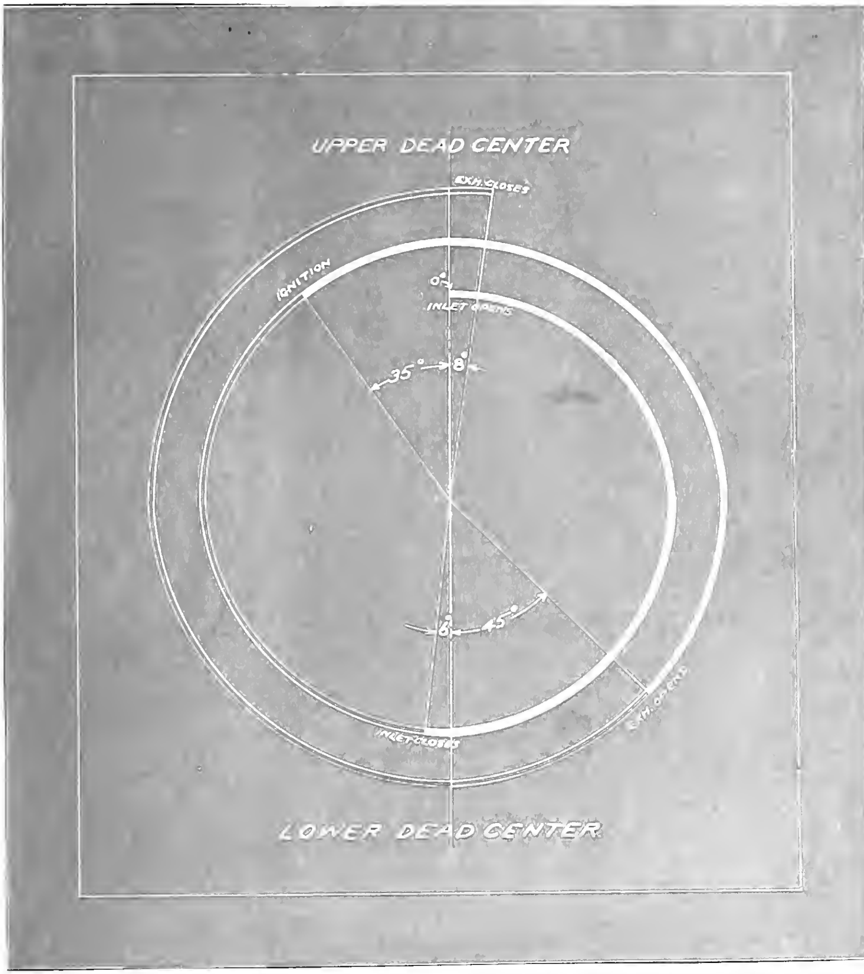


Figure 14.

Timing diagram of left cylinder before cam was shifted.

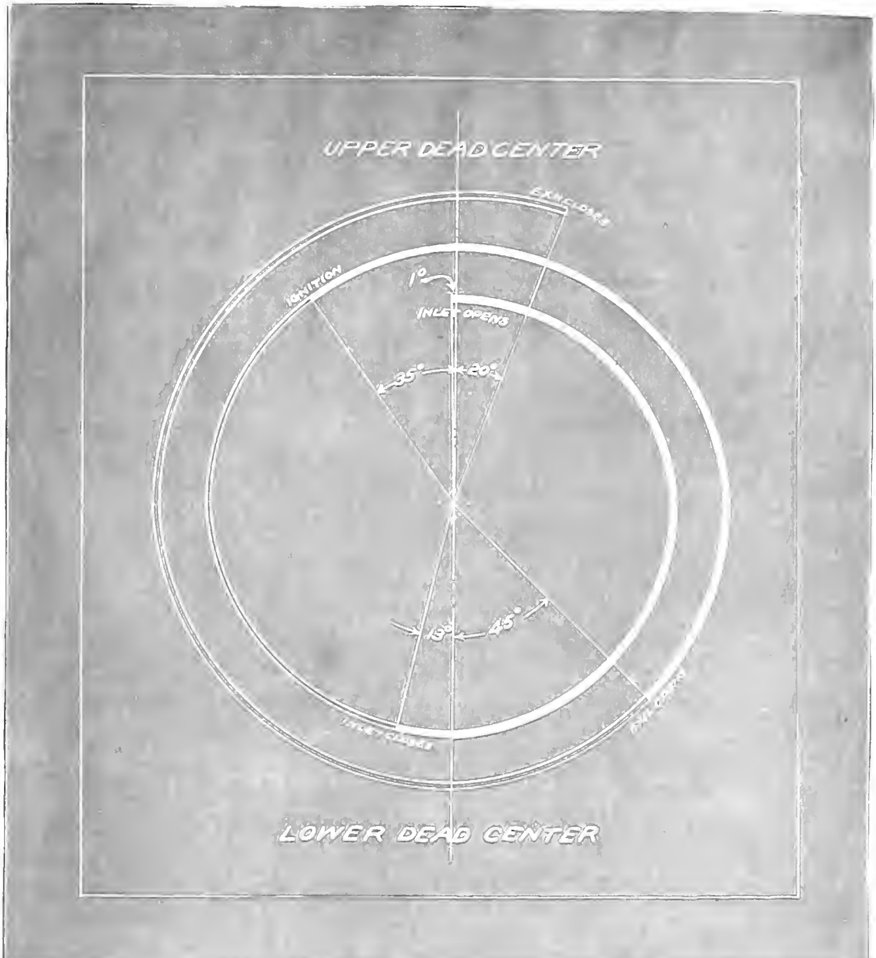


Figure 15.

Timing diagram of right cylinder before cam was shifted.

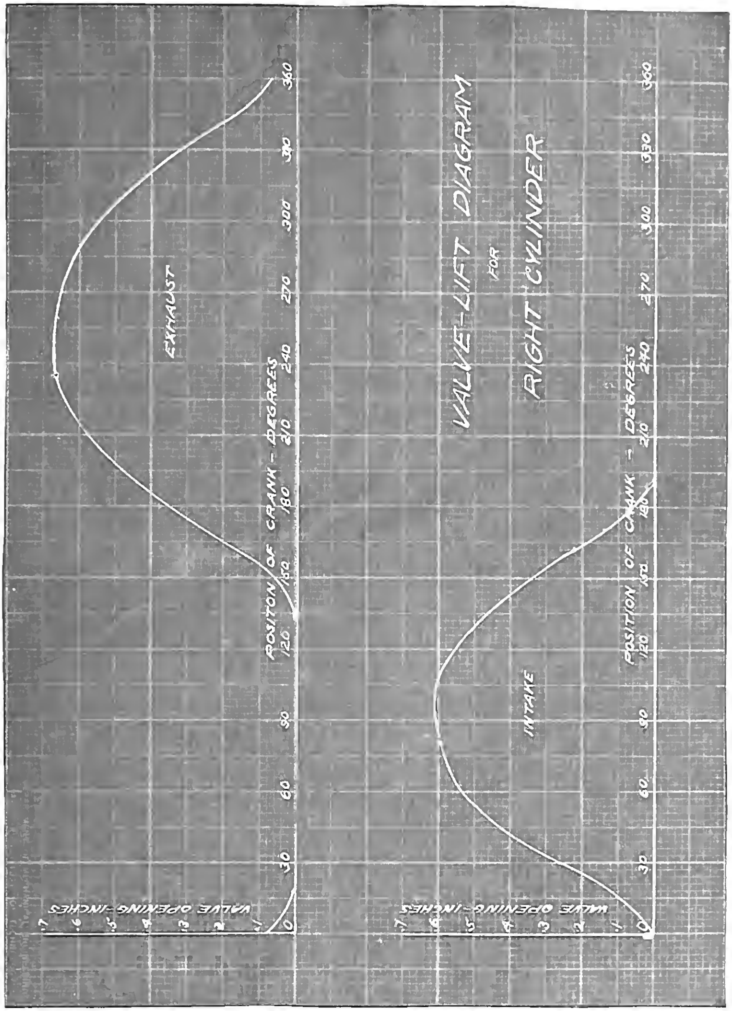


Figure 16.

Valve lift diagram for intake and exhaust valves of the right cylinder.

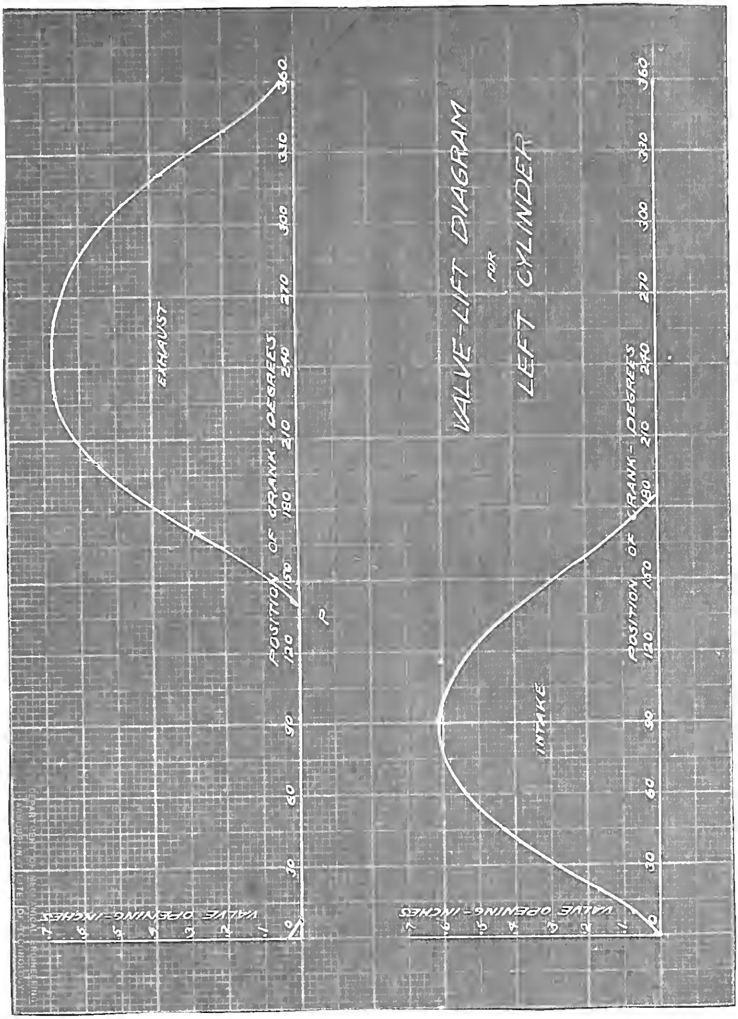


Figure 17.

Valve Lift diagram for intake and exhaust valves of the left cylinder.

CALCULATION.

Gasoline per hour $= \dfrac{\text{Gasoline per run X 60}}{\text{Time of run in minutes}}$

Calorific value of gasoline from Sherman & Kropff formula,

Journal of the American Society of Chemical Engineers, October 1908.

B.T.U. per lb. $= 18650 + 40$ (Degrees Beaume $-$ 10)

Total heat supplied, B.T.U. per hour = Gasoline / hr X BTU / lb.

Actual Indicated Horse Power of each cylinder $= \dfrac{P\ L\ A\ N}{33000}$

Where, P = Mean effective pressure.

L = Length of stroke in feet.

A = Area of piston, sq. in.

N = Number of explosions per min.

Actual Brake Horse Power $= \dfrac{2\ \pi\ r\ G\ N}{33000}$

Where, r = Length of brake arm in feet.

G = Net load on scales

N = Number of revolutions.

Mechanical efficiency $= \dfrac{\text{B.H.P. X 100}}{\text{I.H.P.}}$

B.T.U. / I.H.P. / Hr. $= \dfrac{\text{Total heat supplied}}{\text{I.H.P.}}$

B.T.U. / B.H.P. / Hr. $= \dfrac{\text{Total heat supplied}}{\text{B.H.P.}}$

Gasoline / I.H.P. / Hr $= \dfrac{\text{Total gasoline per hour}}{\text{I.H.P.}}$

CALCULATION (continued)

$$\text{Gasoline / B.H.P. / Hr.} = \frac{\text{Total Gasoline per hour}}{\text{B.H.P.}}$$

$$\text{Heat equivalent of I.H.P.} = \text{I.H.P.} \times 2545$$

$$\text{Heat equivalent of I.H.P. \%} = \frac{\text{I.H.P.} \times 2545 \times 100}{\text{Total heat supplied}}$$

$$\text{Heat equivalent of B.H.P.} = \text{B.H.P.} \times 2545$$

$$\text{Heat equivalent of B.H.P. \%} = \frac{\text{B.H.P.} \times 2545 \times 100}{\text{Total heat supplied}}$$

$$\text{Heat rejected to jacket water} = W (t_1 - t_2)$$

Where, W = Weight of water supplied per hour.

t_1 = Temperature of water leaving jacket.

t_2 = Temperature of water entering jacket.

Heat rejected in exhaust, radiation, and incomplete incombustion,

= 100% - Heat equivalent of I.H.P.

- Heat rejected in jacket water, %.

Test Number 1, March 4, 1914.

I.H.C. Victor 2 Cylinder, 4 Cycle Gasoline Engine.

Rated Horse Power 25, at 335 R.P.M.

Size of cylinders, 8" X 10"

Barometer 29.47 inches of mercury.

Weight of Strut and Brake Arm = 21.7 lbs.

Gasoline = 59° Beaume.

Heat Value of Gasoline per lb. = 18650 + 40(59 - 10)

= 18650 + 1960

= 20610 B.T.U.

DATA- TEST # 1.

Number of run		1	2	3	4	5
Duration of run	min.	10	10	15	10	5
Gasoline per run	lbs.	5.34	4.5	4.26	2.58	1.46
Gasoline per hour	lbs.	32.04	27.0	17.04	15.48	17.52
Total heat supplied per hour	BTU	660500	557000	351500	319000	361300
Jacket water per hour	lbs.	879	996	1370	1422	1644
Temp. jacket water	inlet	42.4	42.68	41.5	41.0	40.88
	outlet	110.9	117.1	114.7	114.3	114.3
Revolutions per minute		347.2	341.2	341.2	336.33	332.5
Explosions per minute		"	"	"	"	"
Pressure lbs. per sq. in. abs. left cylinder.						
Maximum		60	82	142	170	173
Before ignition		31	31	43	62	62
At end of expansion		31	24	27	39	43
Pressure lbs. per sq. in. abs. Right cylinder						
Maximum		52.8	101	149	161	235
Before ignition		26.4	26.4	38.4	53	53
At end of expansion		27	24	29	43	43
Mean effective pressure lbs/sq.in. Left Cylinder		33.7	44	56.5	60.8	80.1
Mean effective pressure lbs/sq/in Right Cylinder		32.5	43.5	60.6	70.1	88.4
Actual Brake Horse Power		5.2	10.28	17.05	23.58	29.95
Actual Indicated Horse Power		14.59	18.93	25.41	27.99	35.58
Mechanical Efficiency		35.6	54.23	67.05	84.3	84.3

DATA- TEST # 1 (continued)

B.T.U./I.H.P./Hr.		45300	29400	13800	11410	9795
B.T.U./B.H.P./Hr.		127100	54250	20600	13530	12050
Gasoline/I.H.P./Hr.	lbs.	2.2	1.43	.67	.564	.492
Gasoline/B.H.P./Hr.	lbs.	6.16	2.63	1.0	.657	.585
Heat equivalent of IHP	BTU	37150	48200	64700	71200	91250
" " Eff.	%	5.63	8.67	18.5	22.38	25.18
Heat rejected in jacket water	BTU	60230	74050	100400	104300	120600
" " " "	%	9.14	11.25	15.2	15.85	18.3
Heat lost in exhaust, radiation, & incomplete combustion	%	85.23	80.08	66.3	62.73	56.52
Heat equivalent B.H.P.	BTU	13240	26180	43400,	59950	76250
" " "	%	2.01	4.71	12.38	18.85	21.2

SAMPLE INDICATOR CARDS TEST # 1.

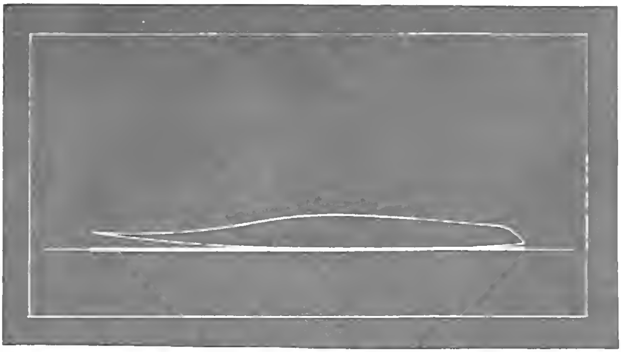
Full Spring Cards;

Cards were taken every minute, the average card for each run being taken as a sample, and included herewith. Scale of spring 240lbs./ in.

Light Spring Cards;

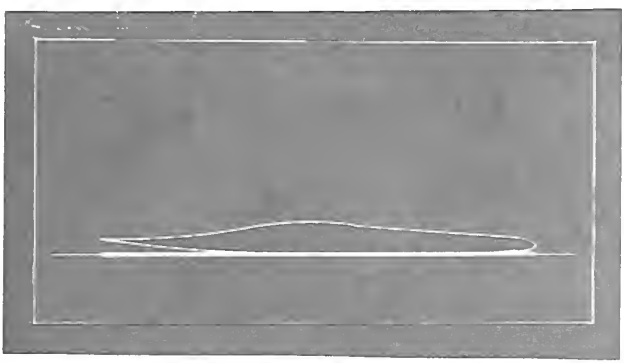
These cards were taken before the regular test was started. Scale of spring 20lbs./in.

RUN #1



Left Cylinder

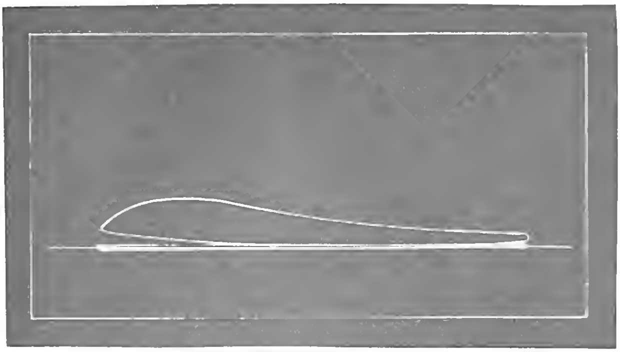
Area	.43	in.
Length	3.04	sq.in.
M.E.P.	33.70	lbs./sq. in.



Right Cylinder

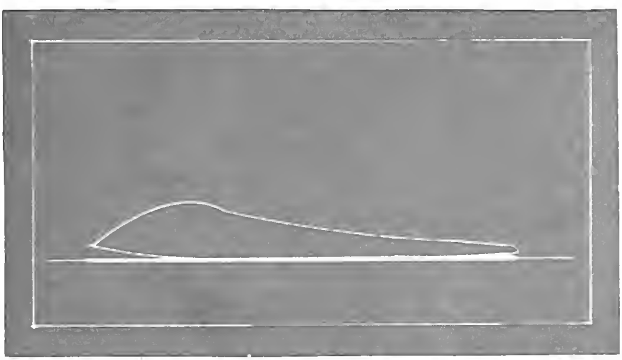
Area	.43	in.
Length	3.02	sq.in.
M.E.P.	32.5	lbs./sq.in.

RUN # 2



Left Cylinder

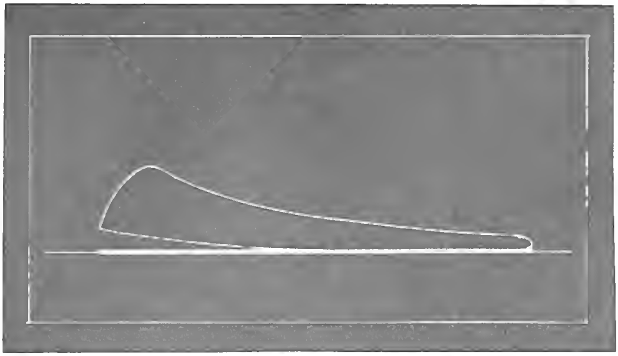
Area	.57 in.
Length	3.00 sq.in.
M.E.P.	46.00 lbs./sq. in.



Right Cylinder

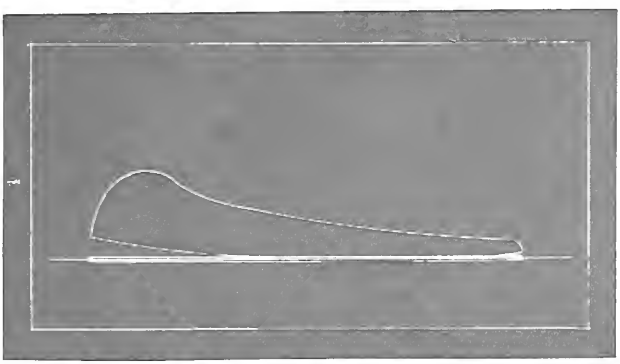
Area	.55 in.
Length	2.99 sq.in.
M.E.P.	44.50 lbs./sq. in.

RUN # 3



Left Cylinder

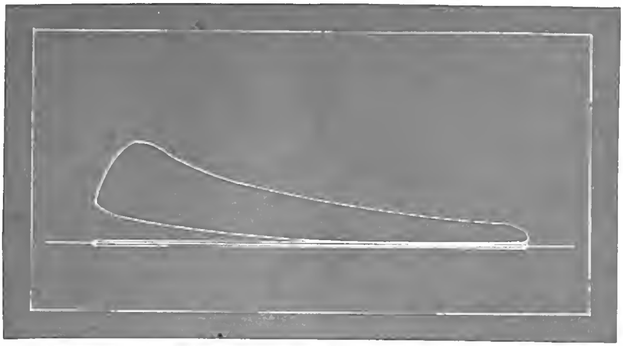
Area	.77	sq. in.
Length	3.03	in.
M.E.P.	61.00	lbs./sq. in.



Right Cylinder

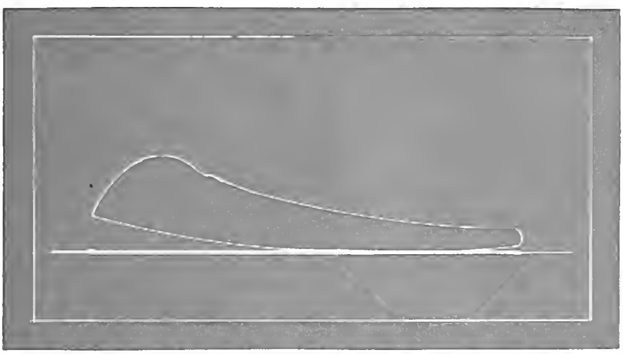
Area	.80	sq. in.
Length	3.02	in.
M.E.P.	63.60	lbs./sq. im.

RUN # 4



Left Cylinder

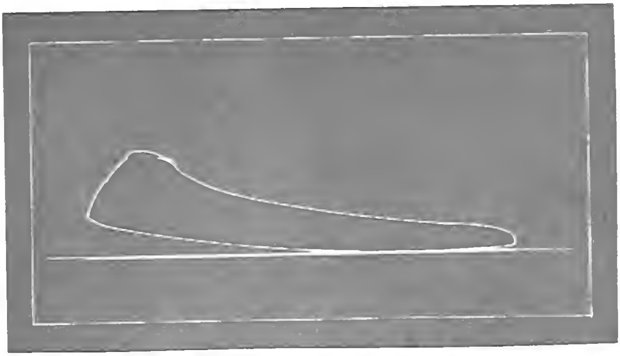
Area	.84	sq. in.
Length	3.03	in.
M.E.P.	66.50	lbs./sq. in.



Right Cylinder

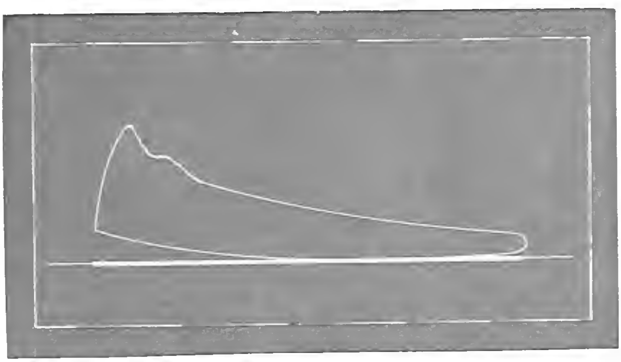
Area	.89	sq. in.
Length	3.03	in.
M.E.P.	70.60	lbs./sq. in.

RUN # 5



Left Cylinder

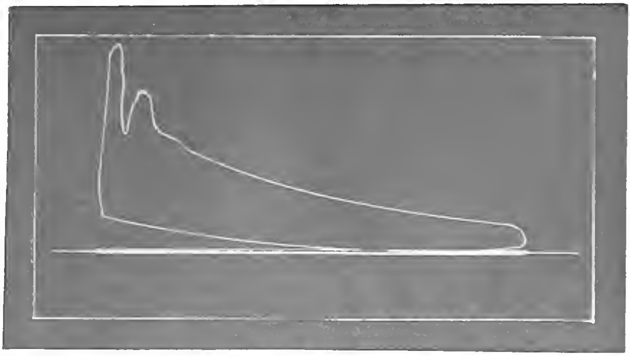
Area	.91 sq. in.
Length	3.01 in.
M.E.P.	72.60 lbs./sq. in.



Right Cylinder

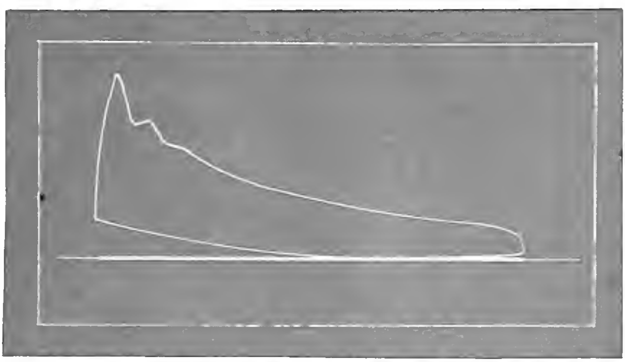
Area	1.06 sq. in.
Length	3.00 in.
M.E.P.	84.80 lbs./sq. in.

RUN # 6



Left Cylinder

Area	1.25	sq. in.
Length	3.00	in.
M.E.P.	108.30	lbs./sq. in.



Right Cylinder

Area	1.27	sq. in.
Length	2.98	in.
M.E.P.	102.20	lbs./sq. in.

Test Number 2, March 30, 1914.

I.H.C. Victor 2 cylinder, 4 Cycle Gasoline Engine.

Rated Horse Power 25, at 335 R.P.M.

Size of cylinders, 8" x 10"

Barometer = 29.58

Gasoline = 59.4^{o} Beaume.

Heat Value of Gasoline per lb. = 18650 + 40 (59.4 - 10)

= 18650 + 1975

= 20625

Weight of Strut and Brake Arm = 21.7 lbs.

DATA - TEST # 2.

Number of run		1	2	3	4	5	6
Duration of run	min.	11	10	10	10	5	6
Gasoline per hour	lbs.	15.5	20.55	24.3	22.1	14.51	20.8
Gasoline per run	lbs.	2.84	3.42	4.06	3.68	1.18	2.08
Total heat supplied/hr	BTU	320000	424500	502000	456000	292000	429500
Jacket water per run	lbs.	188	217	233	297	144	127
" " " hour	lbs.	1025	1303	1398	1782	1728	1270
Temp. Jacket water	inlet	42.4	43.3	42.6	42.0	42.4	41.3
	outlet	107.1	107	108.3	104.7	109.8	111.7
Revolutions per minute		361.5	343.5	336	332.5	331	328
Explosions per minute		"	"	"	"	"	"
Pressure lbs. per sq. in. abs. left cylinder							
Maximum		24	72	96	149	212	252
Before ignition		13	28.8	41	48	50	77
At end of expansion		10	38.5	36	48	48	67.5
Pressure lbs. per sq. in. abs. Right cylinder							
Maximum		48	100	132	157.5	235	243
Before ignition		14	31.4	41	53	67	77
At end of expansion		18.8	28.8	36	48	48	62.4
Mean eff. pressure. #/sq.in	Left cyl	14.04	24.3	47.03	72.85	82.7	96.4
	Right cyl	35.0	50.7	61.3	72.0	84.3	100.6
Actual Indicated Horse Power		12.07	20.05	23.41	31.16	35.69	40.76
Actual Brake Horse Power		5.42	10.3	16.8	23.27	29.8	34.4
Mechanical Efficiency		44.9	51.4	71.7	74.5	83.5	84.8

DATA - TEST # 2 (continued)

B.T.U./ I.H.P. / Hr.		26500	21190	21400	14650	8185	10280
B.T.U. / B.H.P./ Hr.		58100	41250	29850	19590	9820	12490
Gasoline/I.H.P./ Hr.	lbs.	1.285	1.025	1.038	.71	.397	.51
Gasoline/B.H.P./ Hr.	lbs.	2.850	1.995	1.445	.95	.474	.605
Heat equiv. I.H.P. / Hr.	BTU	30720	51000	59650	76750	90850	103800
" " " Eff.	%	9.6	12.0	11.9	16.85	31.05	24.2
Heat rejected to jacket water	BTU	64900	83000	91750	112000	172800	89400
" " " "	%	20.3	19.55	18.3	24.6	59.2	20.8
Heat lost in exhaust, radiation, & incomplete combustion	%	70.1	68.45	69.8	58.55	9.75	55.0
Heat equivalent of B.H.P.	BTU	13780	26250	42800	59250	75850	87600
" " " "	%	4.31	6.18	8.53	13.0	26.0	20.4

SAMPLE INDICATOR CARDS TEST # 2.

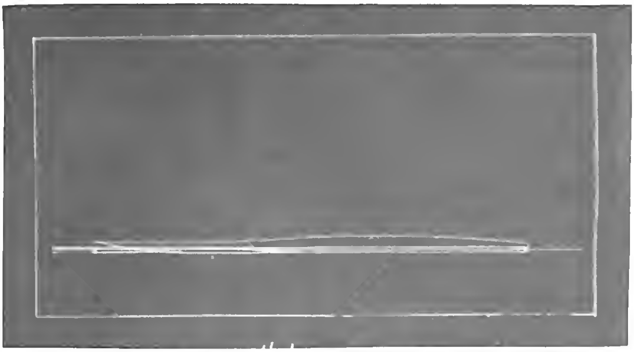
Full Spring Cards;

Cards were taken every minute, the average card for each run being taken as a aample and included herewith. Scale of spring 240 lbs. to 1 in.

Light Sprimg Cards;

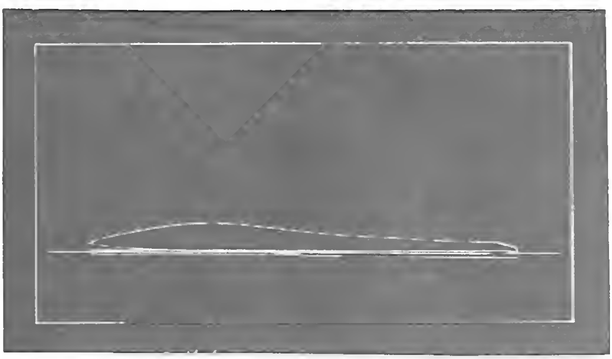
These cards were taken before the regular test was started. Scale of spring 20 lbs. to 1 inch.

Run # 1



Left Cylinder

Area	.17	sq. in.
Length	3.04	in.
M.E.P.	13.40	lbs./ sq. in.

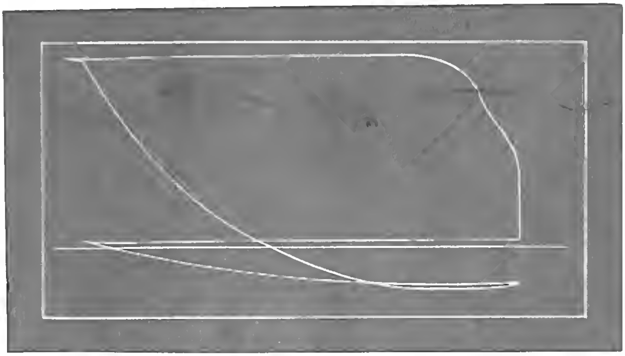


Right Cylinder

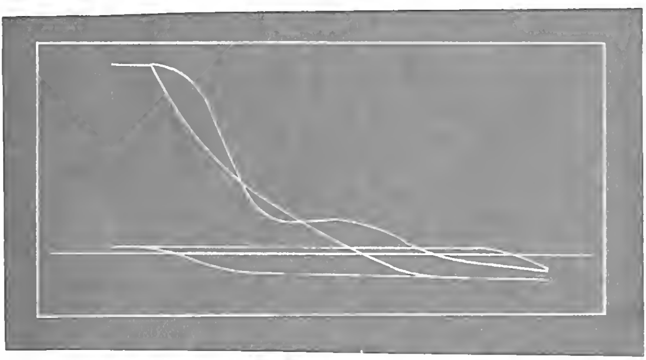
Area	.43	sq. in.
Length	3.01	in.
M.E.P.	34.30	lbs./ sq. in.

RUN # 1

Sample light spring indicator cards.

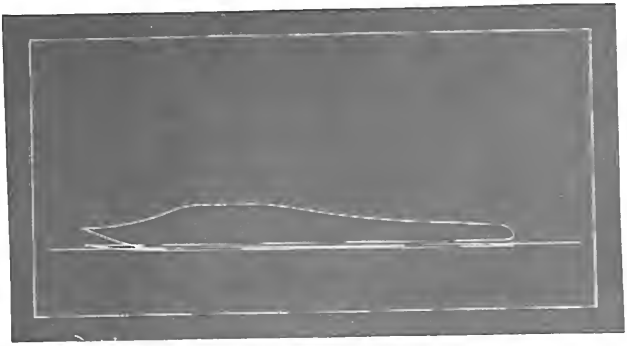


Left cylinder



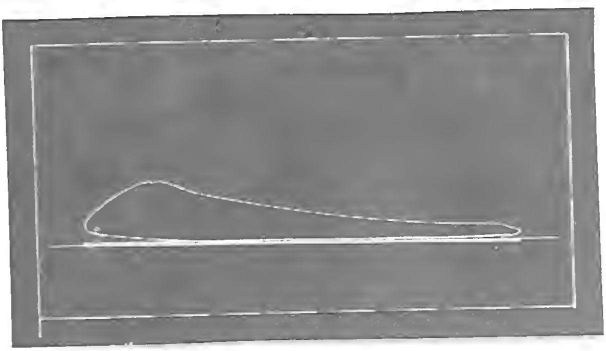
Right cylinder

RUN # 2



Left Cylinder

Area	.49	sq. in.
Length	3.00	in.
M.E.P.	39.20	lbs./ sq. in.

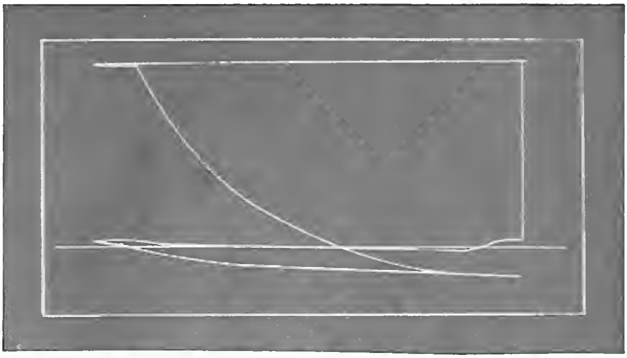


Rgght Cylinder

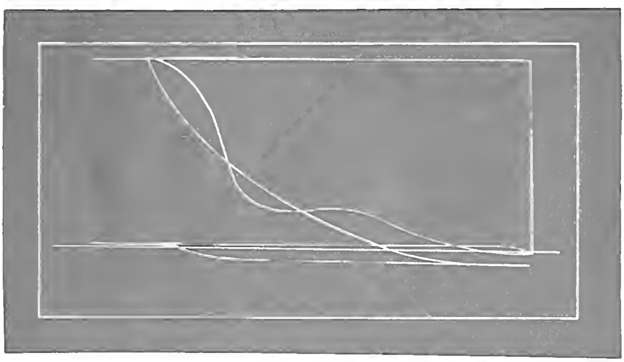
Area	.63	sq. in.
Length	3.03	in.
M.E.P.	49.80	lbs./ sq. in.

RUN # 2

Light Spring Cards

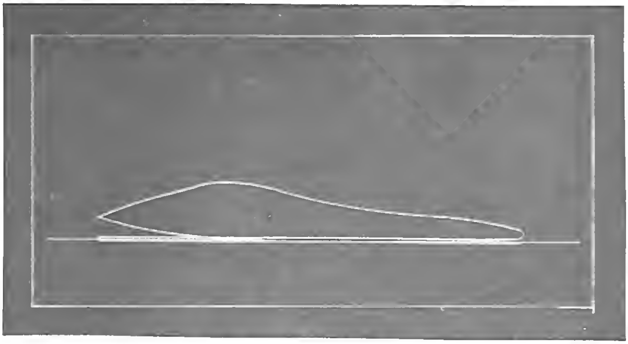


Left Cylinder



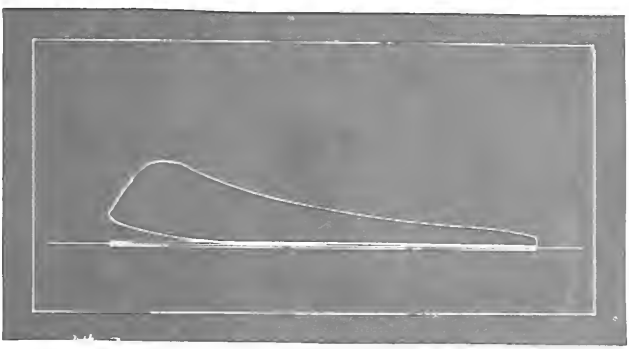
Right Cylinder

RUN # 3



Left Cylinder

Area	.65	sq. in.
Length	3.01	in.
M.E.P.	51.80	lbs./ sq. in.

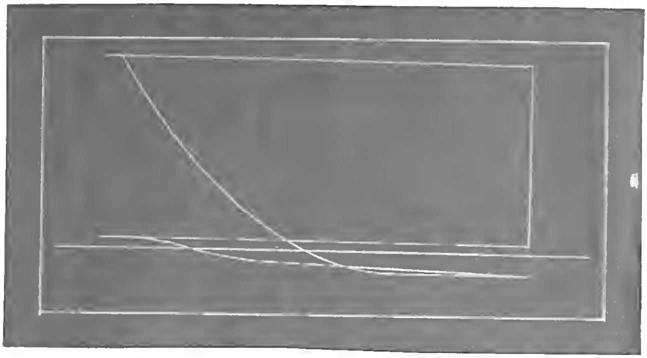


Right Cylinder

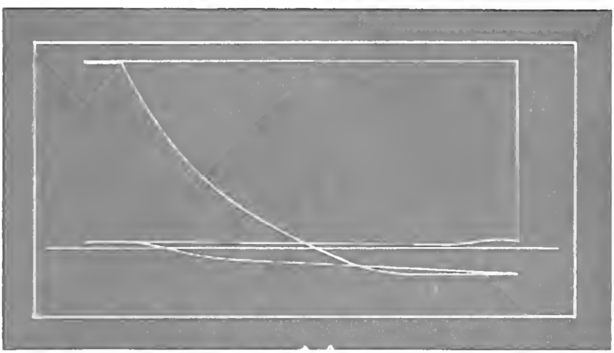
Area	.70	sq. in.
Length	3.00	in.
M.E.P.	56.00	lbs./ sq. in.

RUN # 3

Light Spring Cards

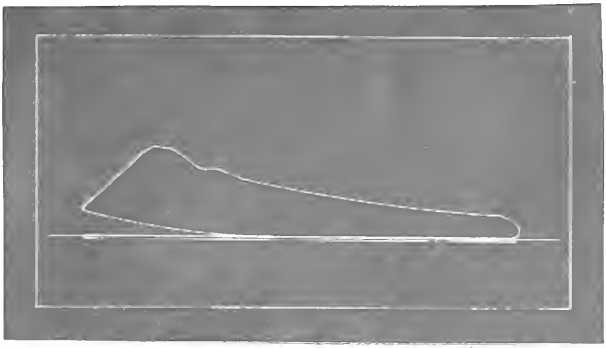


Left Cylinder



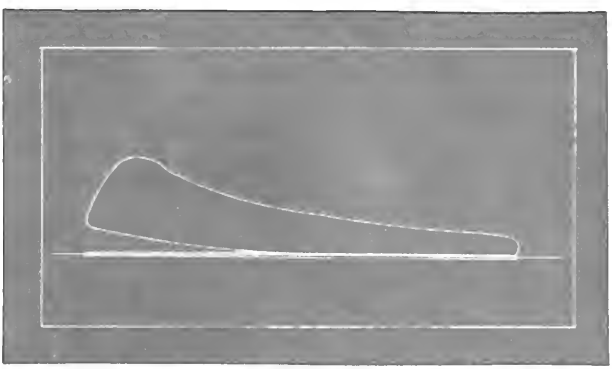
Right Cylinder

RUN # 4



Left Cylinder

Area	.81	sq. in.
Length	3.01	in.
M.E.P.	69.30	lbs./ sq. in.

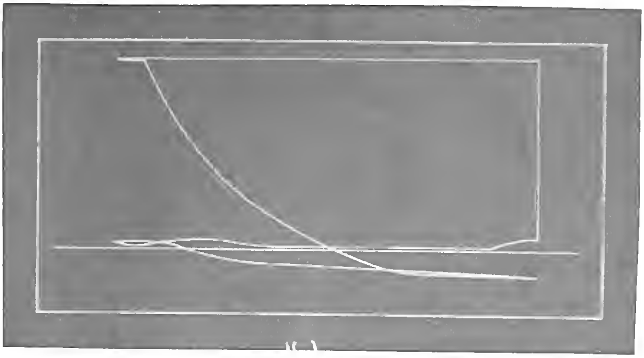


Right Cylinder

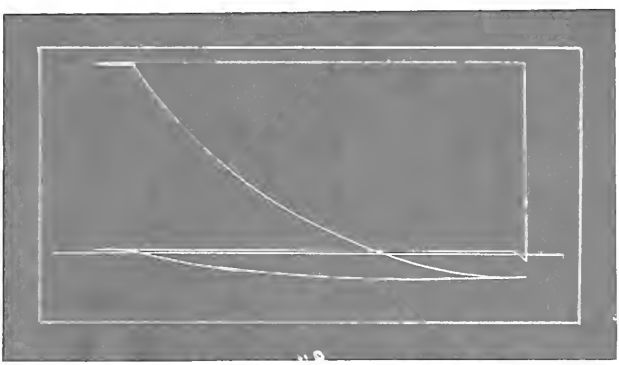
Area	.85	sq. in.
Length	3.02	in.
M.E.P.	67.50	lbs./ sq. in.

RUN # 4

Light Spring Indicator Cards

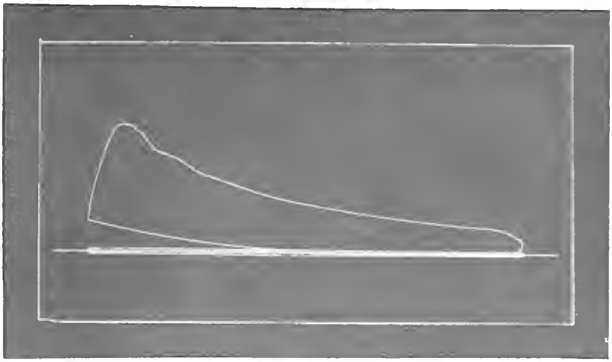


Left Cylinder



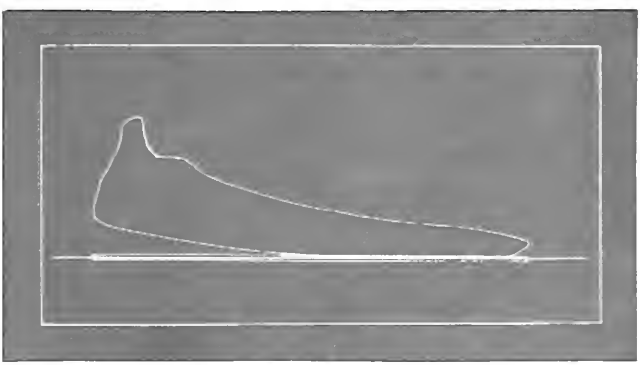
Right Cylinder

RUN # 5



Left Cylinder

Area	1.03 sq. in.
Length	3.05 in.
M.E.P.	81.50 lbs./ sq. in.

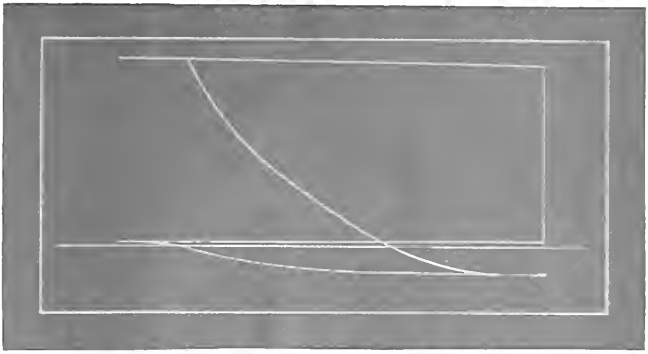


Right Cylinder

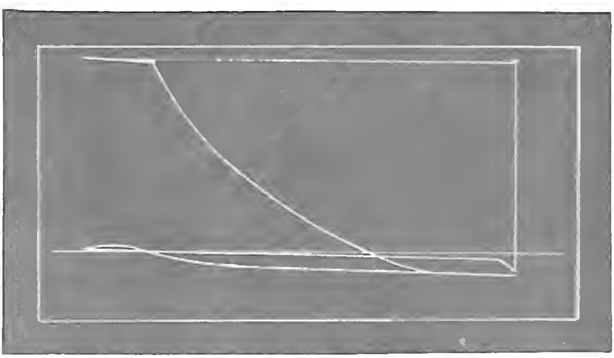
Area	.93 sq. in.
Length	3.00 in.
M.E.P.	74.50 lbs./ sq. in.

RUN # 5

Light Spring Indicator Cards

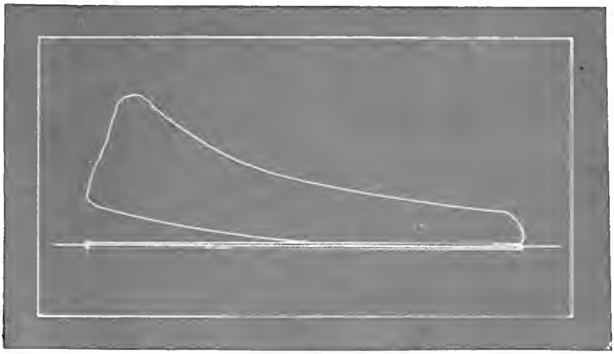


Left Cylinder



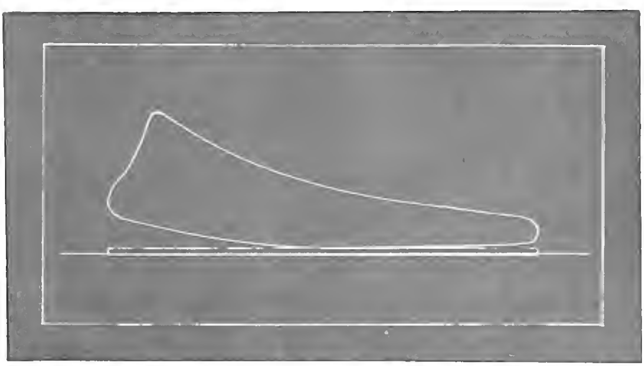
Right Cylinder

RUN # 6



Left Cylinder

Area	1.20	sq. in.
Length	3.03	in.
M.E.P.	95.10	lbs./ sq. in.

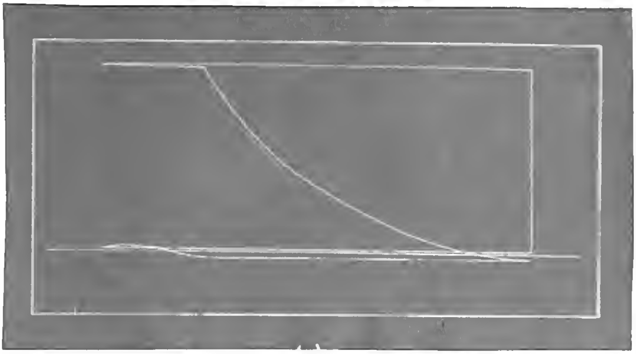


Right Cylinder

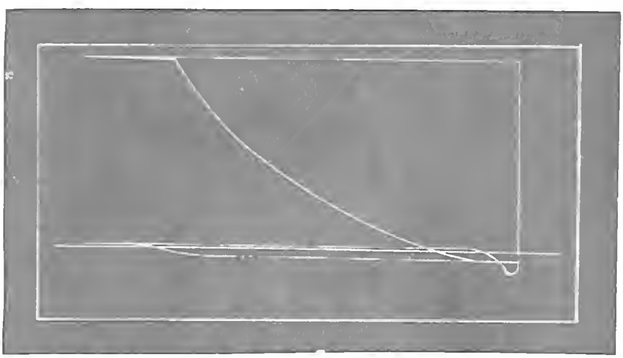
Area	1.31	sq. in.
Length	3.00	in.
M.E.P.	104.70	lbs./ sq. in.

RUN # 6

Light Spring Indicator Cards



Left Cylinder



Right Cylinder

INTRODUCTION TO PART II.

Upon adjusting the exhaust valves to open 45° early, the closing was found to be within limits of ordinary practice, so the exhaust valves were left untouched throughout the test. The inlet valves, however, closed 6° late in the case of the left cylinder, and 13° late in the case of the right cylinder, upon adjusting to open at upper dead center. See Figs. 14, 15, 16, 17. Theoretically the inlet valve should open at 0°, and close about 35° after lower dead center. The eggine is then given the benefit of the inertia of the gasoline vapor entering the cylinder. This affords smoother operation of the valves, the timing being similar to that of an automatic valve regarding the closing point. To effect a closing at 35° past lower dead center, the cams which operate the intake valves were shifted the required amount. To do this, the keys were removed and the cams were shifted 6° and 4° for the left and right cylinders respectively. It was found that the 5/8 inch set screws which the builders had inserted to prevent side slip were sufficient to hold the cams in place for the short time required. Figure 18 shows the method of shifting the cams, A

representing the number of degrees that the cams were shifted. Figs. 19 and 20 show the timing of the valves after shifting the cams. The following data, curves and indicator cards are the results of a test made under these conditions.

PART II.

The Efficiency and Capacity of a 25 Horse Power International Harvester Company Gasoline Engine after changing the relative positions of the cams of the intake valves and their cam shaft

Figure 18.

Diagram showing shifting of cam upon cam shaft.

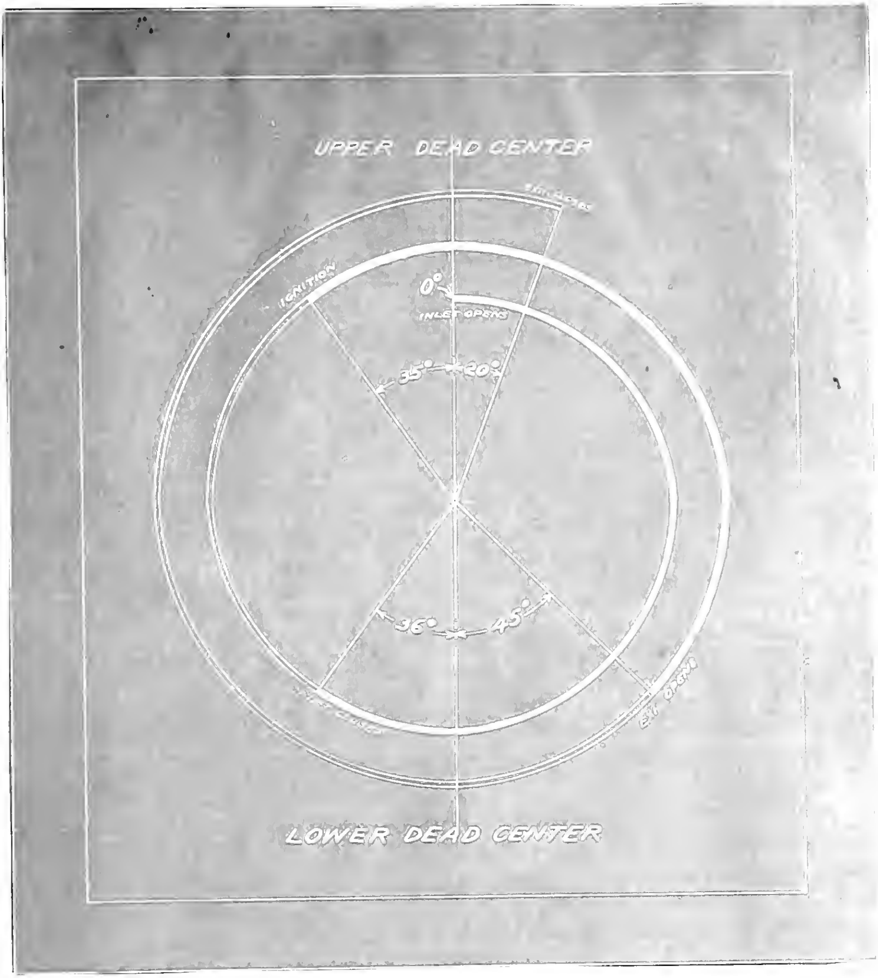


Figure 19.

Timing diagram of right cylinder after shifting the cams.

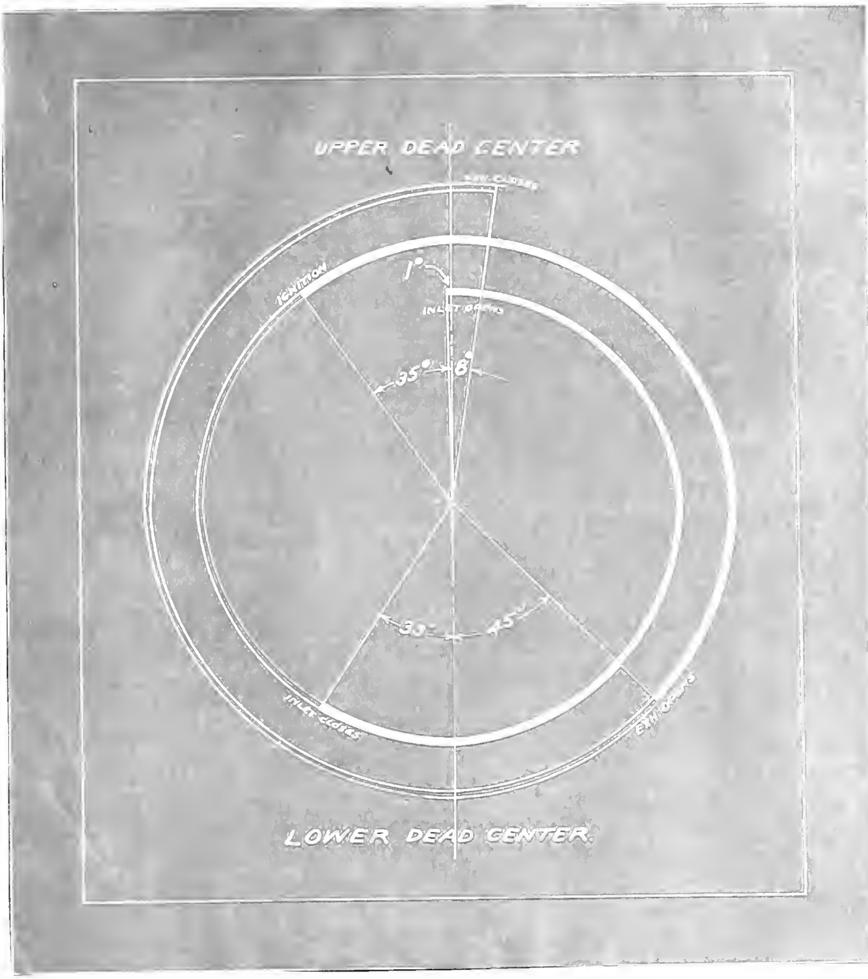


Figure 20.

Timing diagram of left cylinder after shifting the cams.

Test Number 3, April 20, 1914.

I.H.C. Victor 2 Cylinder, 4 Cycle Gasolie Engine.

Rated Horse Power 25, at 335 R.P.M.

Size of cylinders, 8" x 10".

Barometer = 29.49

Weight of Strut and Brake Arm = 21.7 lbs.

Gasoline = 58.85° Beaume.

Heat Value of Gasoline per lb. $= 18650 + 40\ (58.85 - 10)$

$= 18650 + 1955$

$= 20605$ B.T.U.

DATA - TEST # 3.

Number of run		1	2	3	4	5	6
Duration of run		10	10	10	10	5	5
Gasoline per run	lbs.	2.72	2.56	2.46	2.28	1.38	2.60
Gasoline per hour	lbs.	16.32	15.36	14.76	13.68	16.56	31.2
Total heat supplied / hour	BTU.	336800	316700	304200	282000	341400	643500
Jacket water per hour	lbs.	1212	1327	1471	1687	2388	2266
Temp. jacket water inlet		46.5	46.5	46.3	45.7	45.0	45.0
outlet		109.5	105.7	117.1	112.5	99.0	95.6
Revolutions per minute		387.5	380.5	343.5	338.5	337	326
Explosions per minute		"	"	"	"	"	"
Préssure lbs, per sq. in. abs. left cylinder							
Maximum		29.0	86.5	122	165	203	210
Before ignition		24.0	36.0	42.5	59.0	47.0	68.5
At ebd of expansion		21.8	19.0	28.1	30.8	36.4	59.0
Pressure lbs. per sq. in. abs. Right cylinder							
Maximum		77.0	84.0	130.0	162	242	191
Before ignition		36.0	24.0	54.3	59.0	59.0	75.5
At end of expansion		21.8	19.0	28.1	35.4	42.5	61.4
Mean effective preesure lbs. per sq. in.							
Left Cylinder		22.2	27.4	49.6	70.8	79.9	93.5
Right "		34.7	38.8	54.86	65.73	82.1	99.0

DATA - Test # 3 (continued)

Total indicated horse power	14.0	16.00	22.79	29.69	34.24	39.75
Actual brake horse power	5.81	11.42	17.17	23.7	31.3	35.85
Mechanical efficiency %	41.5	71.3	75.4	79.8	91.4	90.25
B.T.U./ I.H.P./ Hr.	24050	19800	13350	9500	9960	16200
B.T.U./ B.H.P./ Hr.	58050	27740	17740	11900	10910	16560
Gasoline / I.H.P. / Hr. lbs.	1.165	.959	.647	.461	.483	.786
Gasoline / B.H.P. / Hr. lbs.	2.805	1.345	.859	.577	.529	.870
Heat equiv. I.H.P. BTU.	35650	40700	58000	75600	87200	101200
" " " eff. %	10.59	12.88	19.05	26.8	25.55	15.71
Heat rejected in jacket water BTU.	76400	78700	10420	11280	12900	11480
Heat rejected in exhaust & lost thru radiation BTU	66.71	62.32	46.75	33.33	36.70	66.44
Heat equiv. of B.H.P. BTU	14800	29080	43700	60300	79700	91250
" " " " eff. %	4.39	9.19	14.38	21.40	23.35	14.40

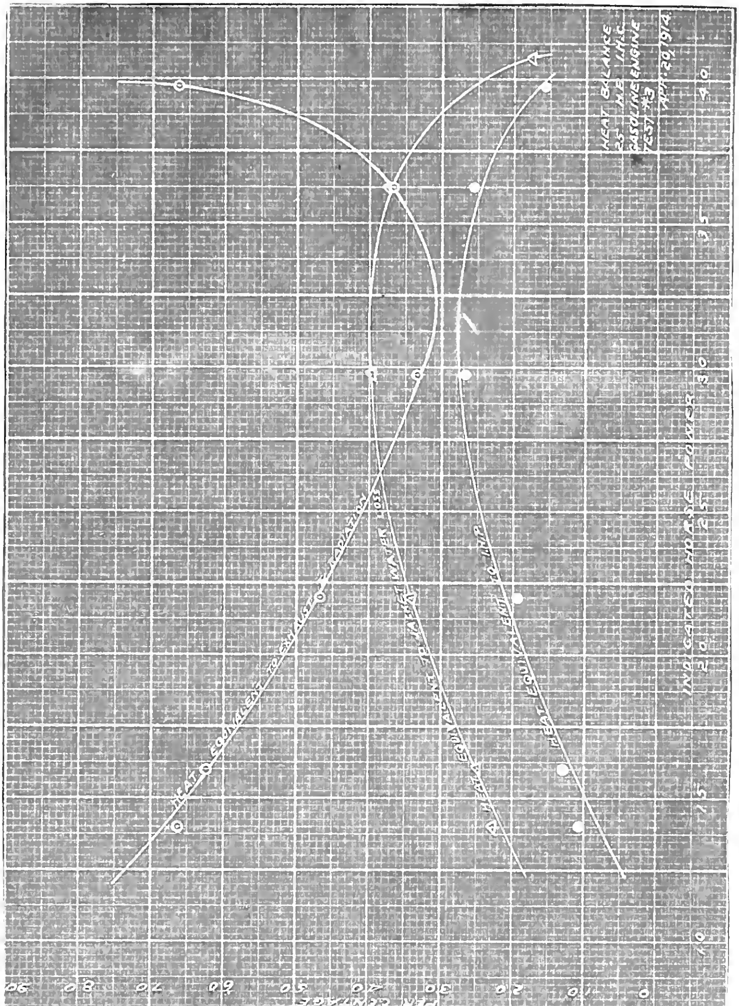

HEAT BALANCE
25 H.P. I.H.C.
GASOLINE ENGINE
TEST #3
APR. 20, 1914
INDICATED HORSE POWER
PER CENTAGE
HEAT EQUIVALENT TO JACKET WATER LOSS
HEAT EQUIVALENT TO I.H.P.

Figure 21.

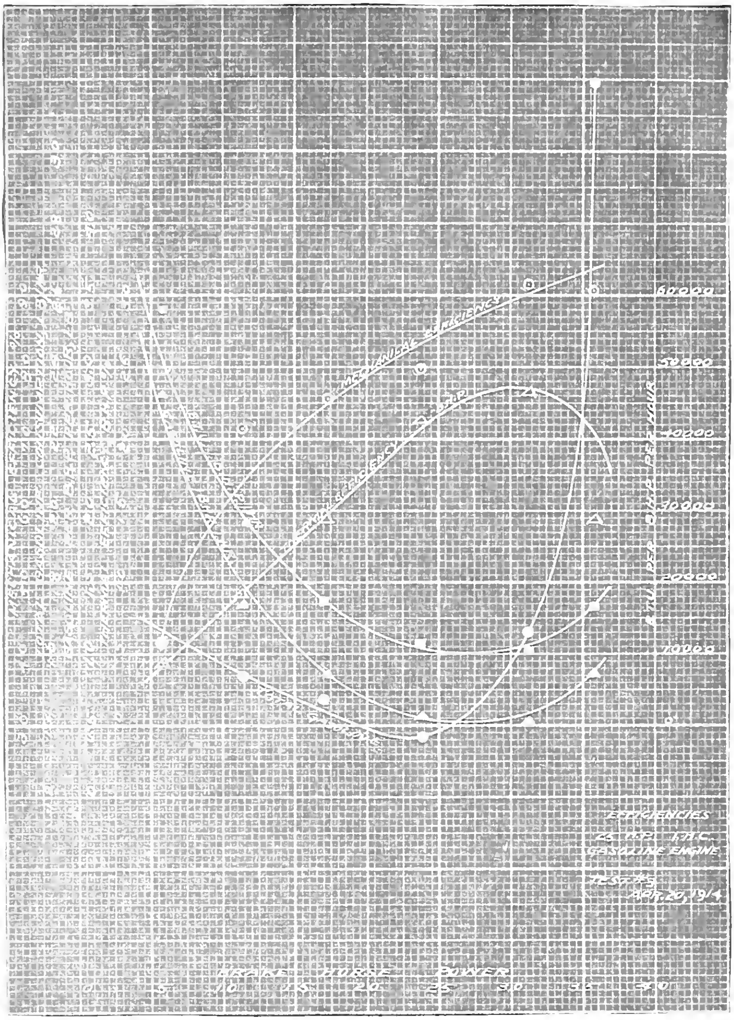

MECHANICAL EFFICIENCY
THERMAL EFFICIENCY B.H.P.
60000
50000
40000
30000
20000
10000
B.T.U. PER B.H.P. PER HOUR
EFFICIENCIES
25 H.P. I.H.C.
GASOLINE ENGINE
TEST #5
APR. 20, 1914
BRAKE HORSE POWER
5
10
15
20
25
30
35
40

Figure 22.

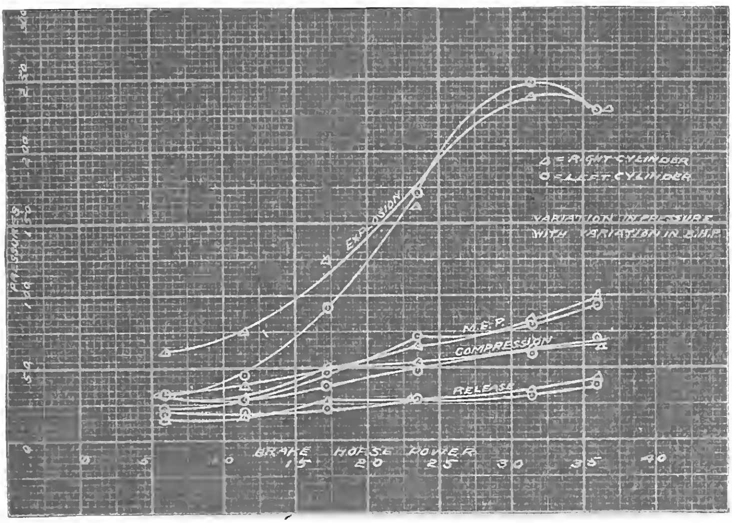

△ = RIGHT CYLINDER
O = LEFT CYLINDER
VARIATION IN PRESSURE
WITH VARIATION IN B.H.P.
EXPLOSION
M.E.P.
COMPRESSION
RELEASE
PRESSURES
0
50
100
150
200
250
300
BRAKE HORSE POWER
0
5
10
15
20
25
30
35
40

Figure 23.

SAMPLE INDICATOR CARDS TEST # 3.

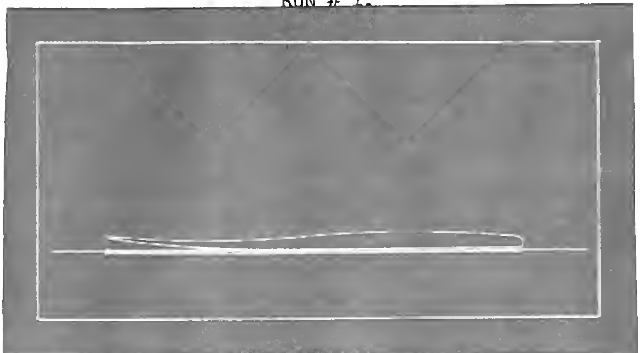
Full Spring Cards;

Cards were taken about once a minute, the average card being taken as a sample, and included herewith. Scale of spring 240 lbs to 1 inch.

Light Spring Cards;

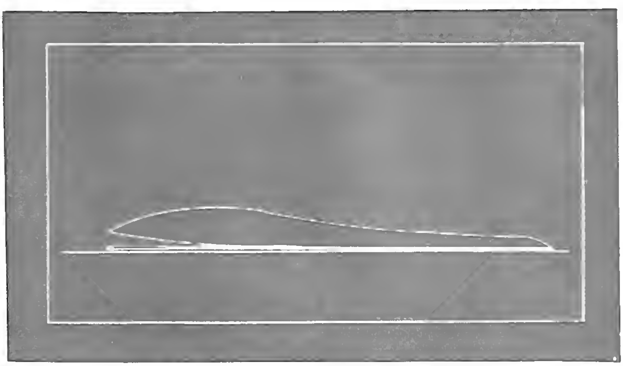
These were taken before the regular test was started. Scale of spring 20 lbs to 1 inch.

RUN # 1.



Left Cylinder

Area	.24	sq. in.
Length	2.94	in.
M.E.P.	19.60	lbs./ sq. in.

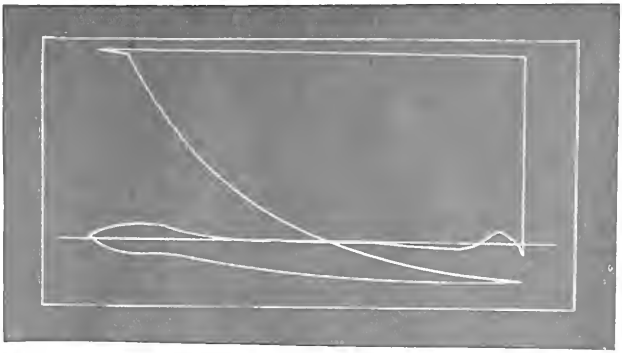


Right Cylinder

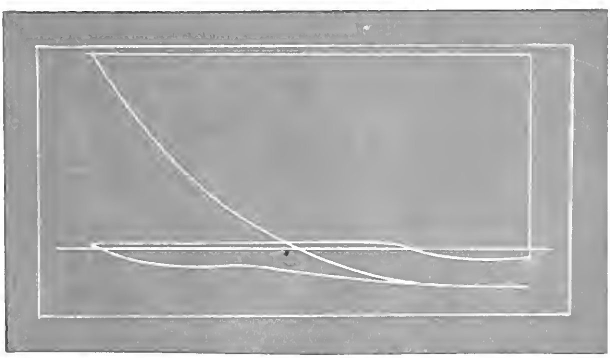
Area	.45	sq. in.
Length	3.12	in.
M.E.P.	34.60	lbs./ sq. in.

RUN # 1.

Sample Light Spring Indicator Cards.

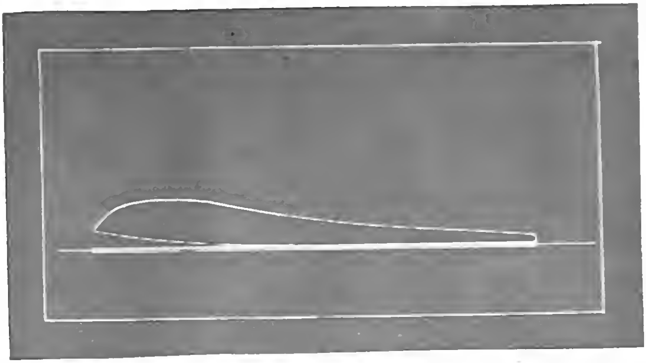


Left Cylinder



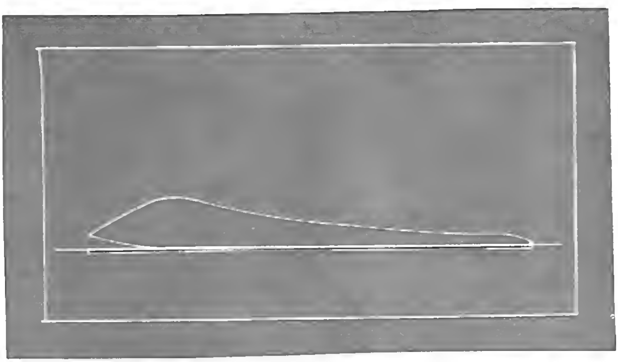
Right Cylinder

RUN # 2.



Left Cylinder

Area	.50	sq.in.
Length	3.11	in.
M.E.P.	38.60	lbs./sq.in.

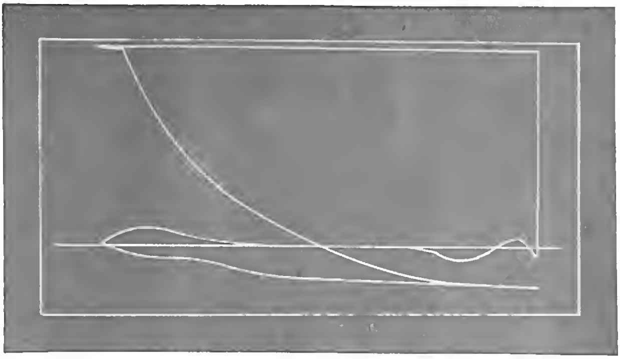


Right Cylinder

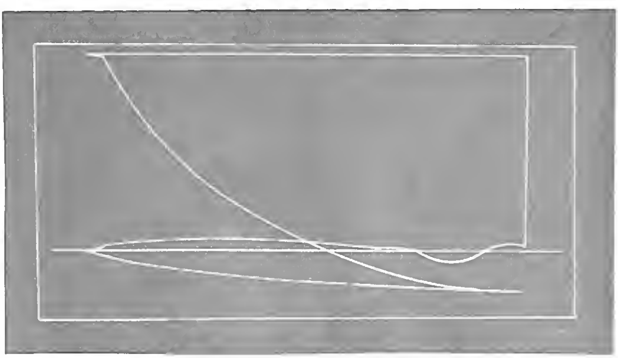
Area	.57	sq.in.
Length	3.10	in.
M.E.P.	44.10	lbs./sq.in.

RUN # 2.

Sample Light Spring Indicator Cards.

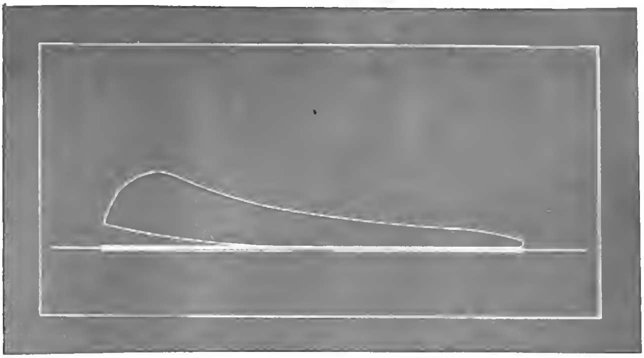


Left Cylinder



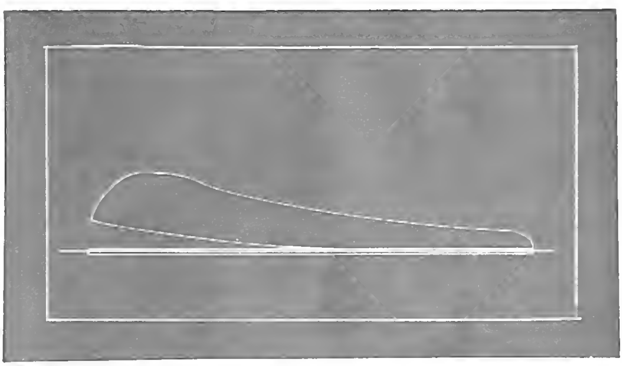
Right Cylinder

RUN # 3.



Left Cylinder

Area	.68	sq,in,
Length	2.95	in.
M.E.P.	55.00	lbs./sq.in.

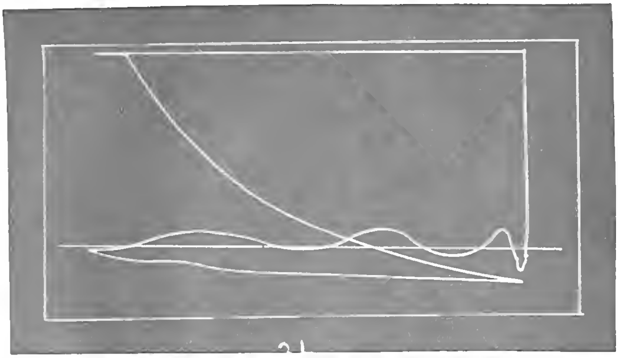


Right Cylinder

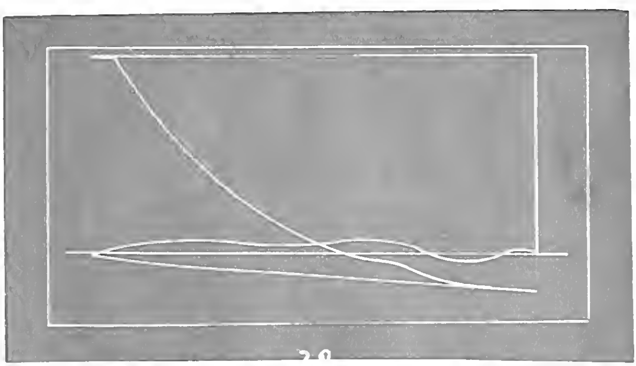
Area	.77	sq.in.
Length	3 .10	in.
M.E.P.	59.60	lbs./sq.in.

<u>RUN # 3.</u>

S ample Light Spring Indicator Cards.

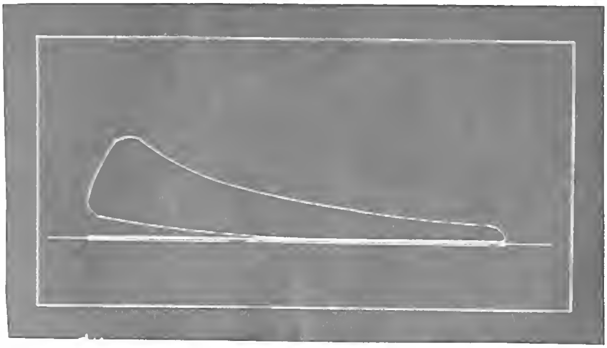


Left Cylinder



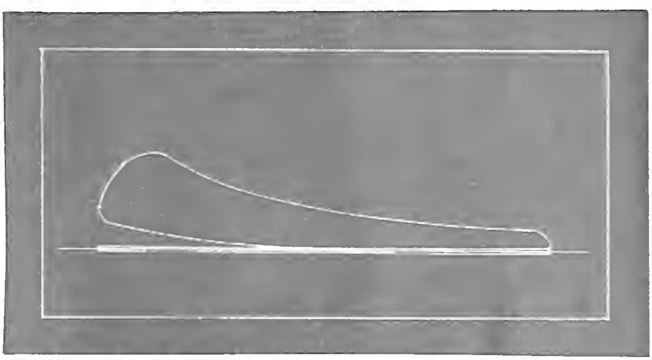
Right Cylinder

RUN # 4.



Left Cylinder

Area	.93	sq.in.
Length	2.91	in.
M.E.P.	76.70	lbs./sq.in.

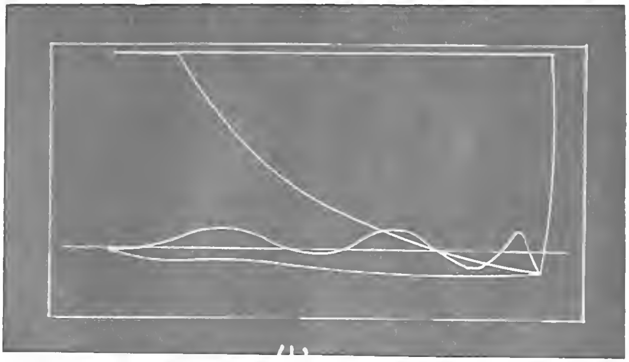


Right Cylinder

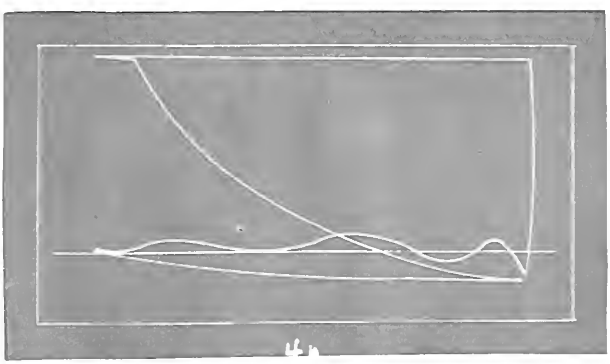
Area	.89	sq.in.
Length	3.11	in.
M.E.P.	68.70	lbs./sq.in.

<u>RUN # 4.</u>

Sample Light Spring Indicator Cards.

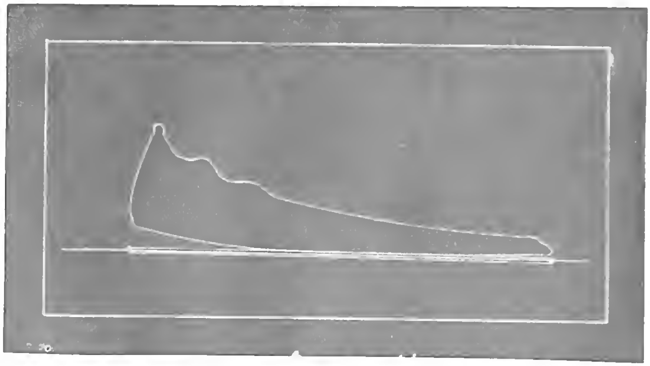


Left Cylinder



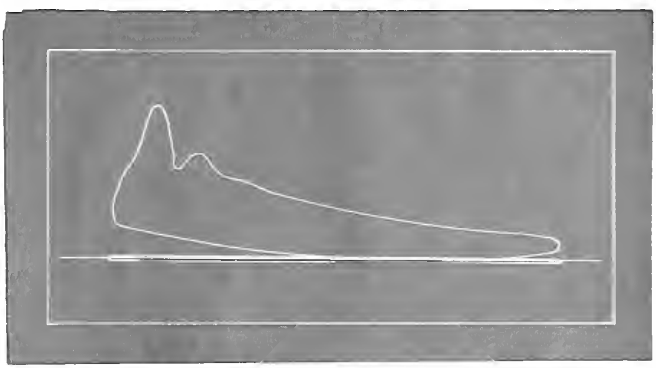
Right Cylinder

RUN # 5.



Left Cylinder

Area	.93 sq.in.
Length	2.91 in.
M.E.P.	76.60 lbs./sq.in.

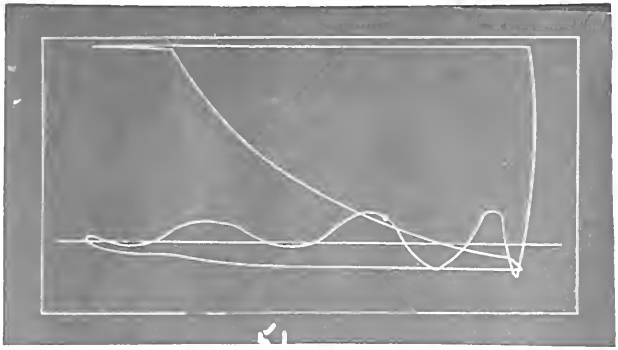


Right Cylimder

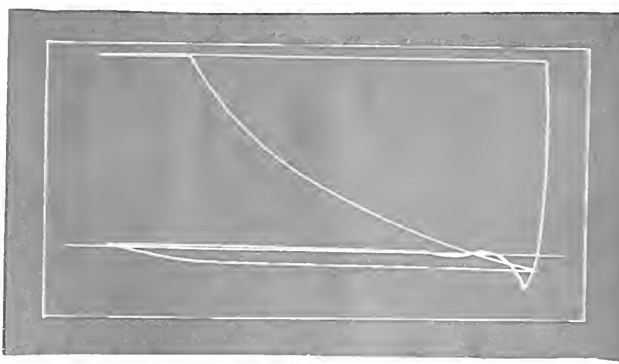
Area	1.03 sq.in.
Length	3.13 in.
M.E.P.	79.00 lbs./sq.in.

RUN # 5.

Sample Light Spring Indicator Cards

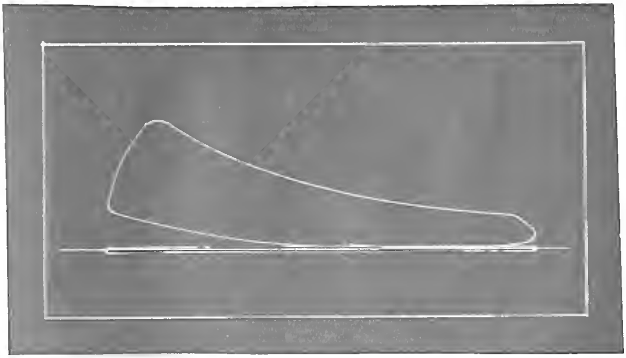


Left Cylinder



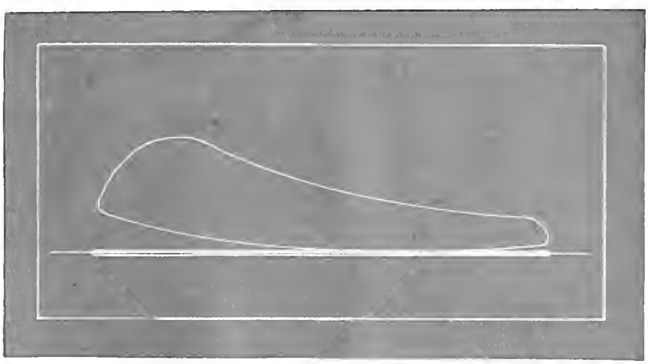
R ight Cylinder

RUN # 6.



Left Cylinder

Area	1.20	sq.in.
Length	2.92	in.
M.E.P.	98.70	lbs./sq.in.

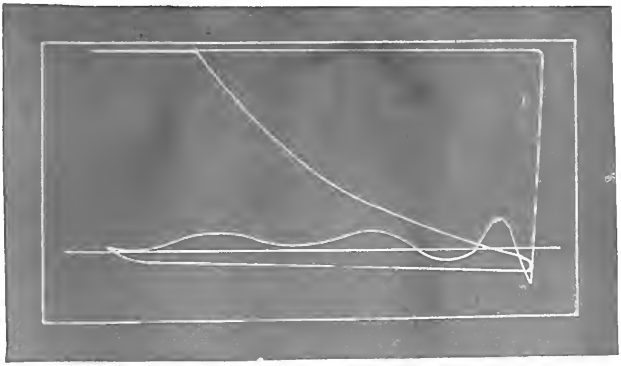


Right Cylinder

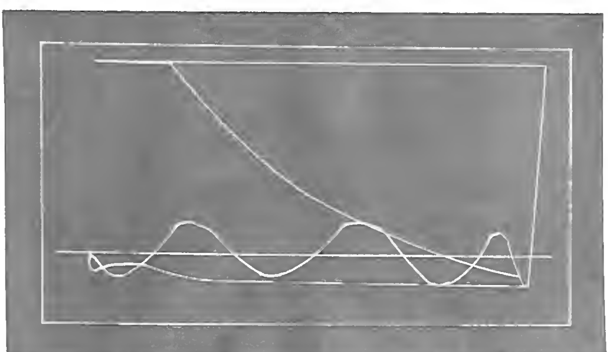
Area	1.27	sq.in.
Length	3.12	in.
M.E.P.	97.60	lbs./sq.in.

RUN #6.

Sample Light Spring Indicator Cards



Left Cylinder

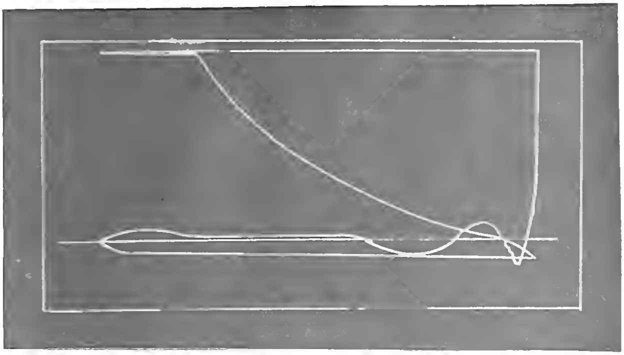


Right Cylinder

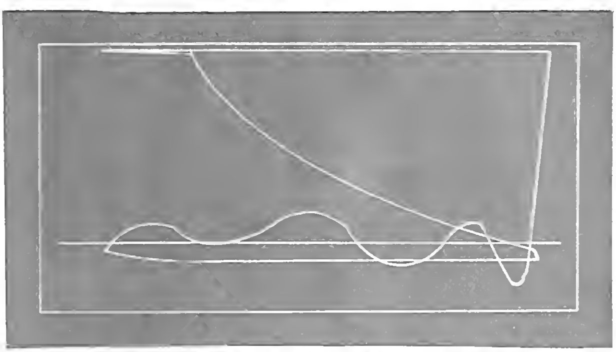
OPEN THROTTLE
INDICATOR CARDS * 20# SPRING

The following cards were taken at each change in load, holding the throttle valve wide open for a period of time long enough to take the card. This gives the maximum per cent of filling, which is illustrated on the cards as the ratio of the total length to the distance betwean the points where the expansion and intake lines cut the atmospheric line.

RUN # 1.

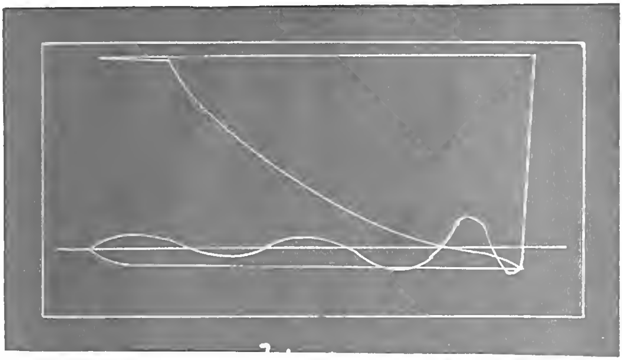


Left Cylinder

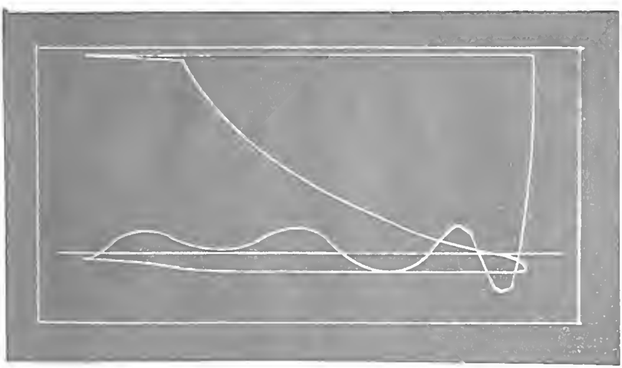


Right Cylinder

<u>RUN # 2.</u>

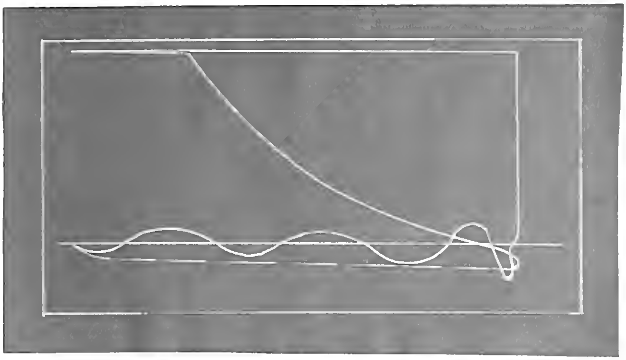


Left Cylinder

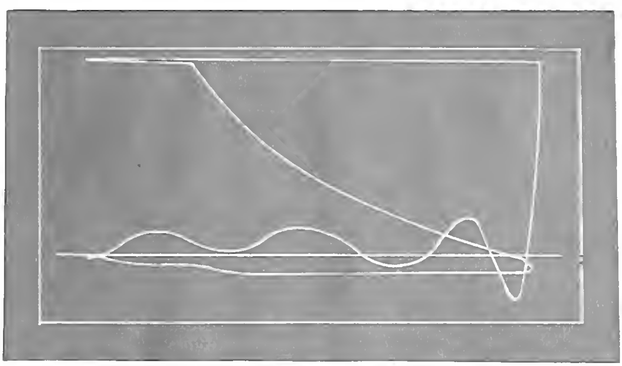


Left Cylinder

RUN # 3.

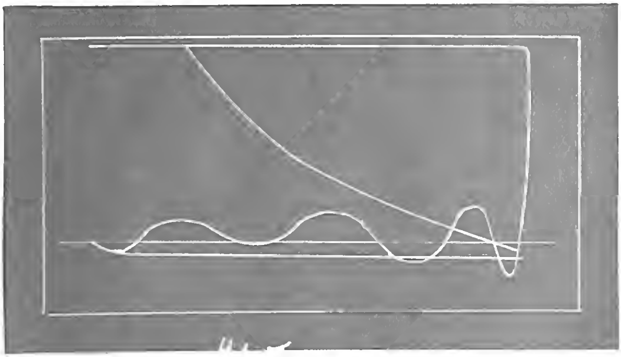


Left Cylinder

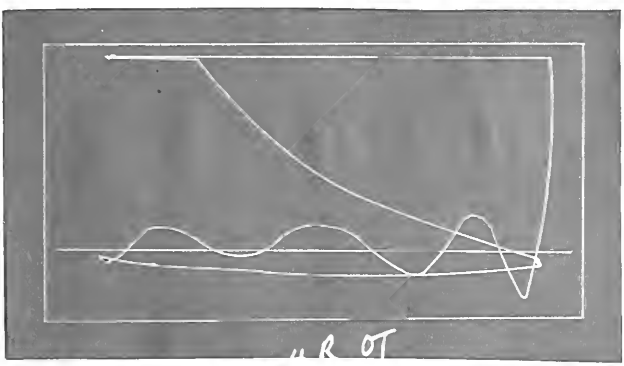


Right Cylinder

RUN # 4.

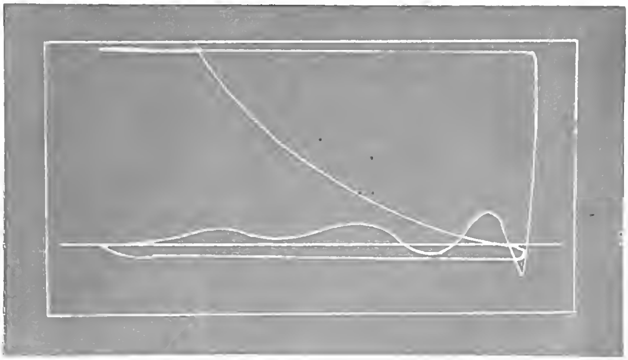


Left Cylinder

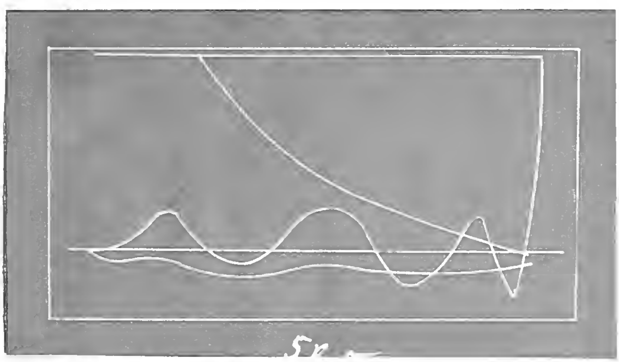


Right Cylinder

RUN # 5.

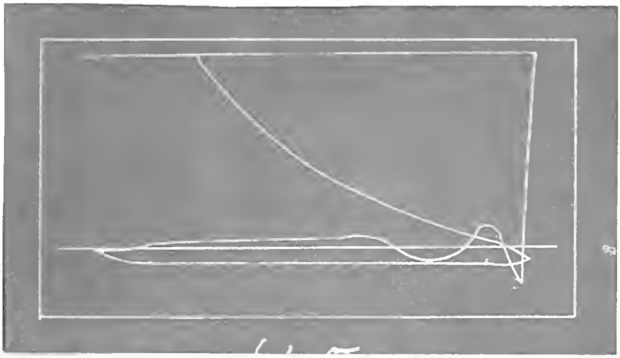


Left Cylinder

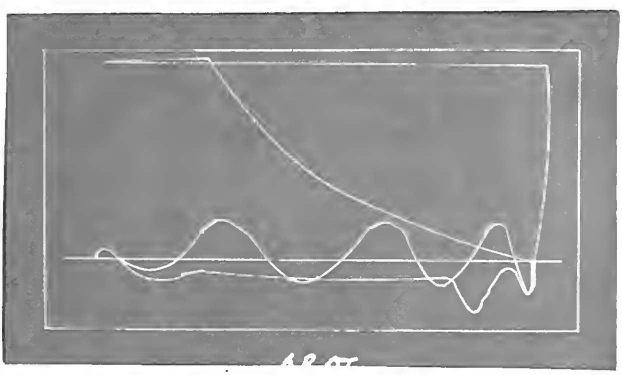


Right Cylinder

RUN # 6.



Left Cylinder



Right Cylinder

General Conclusions

Considering all the factors which enter into the subject, test number 3, which was made after the cams were shafted shows a better all-round efficiency. The high gasoline consumption at low loads is due to the fact that all the tests were made with a constant needle valve setting, adjusted at full load. At low loads the engine was receiving a rich mixture, and was missing badly. This results in a high gasoline consumption. With a properly designed valve in the mixing chamber however better results could be obtained. The maximum power was slightly increased, from 29.9 H.P. in test number one and 34.4 H.P. in test number 2, to 35.85 H.P. in test number 3. It should be noted that no water was injected into the cylinders at overload.

It is probable that the intake valves were held open too long, for the wavy exhaust on the indicator cards illustrates a burning exhaust and variable pressure. The mechanical efficiency however was greatly increased.

We are indebted to the following students for valuable assistance in making the various tests;

L. E. Hibbard	'15
H. H. Gwinn	'16
F. L. Brewer	'15
G. S. Cooley	'14
F. B. Faulkner	'15

Oscar Goetz.

[illegible]